X. HISTORICAL INFORMATION ON COSTS

A. 1984 ARB STAFF SURVEY

1. Data Base

In 1984 the staff conducted a survey of California refiners to obtain information on the costs of producing diesel fuel that would meet a range of specifications for aromatic hydrocarbon content, sulfur content, and 90 percent distillation temperature. Eleven refiners responded to this survey. The projected diesel fuel production for these refiners for 1990 would represent about 97 percent of the projected diesel fuel demand for 1990. Table 14 summarizes the costs that the 11 refiners reported. The table includes the investment costs for capital equipment to produce the specified diesel fuels, the operating costs, and the total incremental costs.

2. Capital and Operating Costs

To present a comparative cost estimate, we used the survey responses to calculate the investment cost on the basis of cents per gallon of diesel fuel produced. The capital costs have been annualized using an annual capital charge factor of 0.25. The operating costs are shown as reported and include the process operating costs and the costs of additional crude oil purchases, if required. All estimates are in 1983 dollars. Table 14 shows the operating costs as reported by the oil companies in the 1984 survey. The total annual costs are the sum of the capital costs and the operating costs and are shown in thousands of dollars per day.

Table 14

Summary of Cost*/ Analysis for Each Regulatory Scenario for Small and Large Refiners Based on the 1984 Survey Data

Fuel Composition Requirement	Production Rate**/ (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
0.05% S					
small refiners	15.5	28.2	19.32	28.04	47.36
large refiners	129.7	104.83	71.80	37.63	109.43
0.05% S and 10% Aromatics					
small refiners	9.5	24.00	16.44	28.04	44.48
large refiners	133.0	813.10	556.91	293.64	850.55

*/ All costs in 1983 dollars.
**/ As reported.

3. Cost Per Gallon

Table 15 gives the cost estimated in cents per gallon of diesel fuel produced. The values range from 11.2 to 15.2 cents per gallon for the 10 percent aromatic hydrocarbon case.

4. Cost-Effectiveness

The staff used the costs shown in Table 14 and the emissions reductions shown in Table 12 to estimate the cost-effectiveness ratio for each refinery group and for each regulatory scenario for the year 1995. The cost-effectiveness values presented in Table 15 are for particulate matter (PM), oxides of nitrogen (NOx), PM and NO_x, and total pollutants which includes reductions for sulfur dioxide (SO_2).

B. NPRA SURVEY

1. Data Base

In 1986 the National Petroleum Refiners Association (NPRA) conducted a nationwide survey to establish the refining industry's capacities, capabilities, and costs to comply with a low sulfur or a low aromatic hydrocarbon content regulation. The limits for sulfur content and aromatic hydrocarbon content evaluated by the NPRA survey were 0.05 percent and 20 percent, respectively. Based on information provided by ADL on the NPRA survey data, we performed a cost analysis for small and large refineries operated in California.

Table 15

Cost-Effectiveness of Emission Reductions from Diesel Fuel Sulfur and Aromatics Hydrocarbon Content Reduction Based on the 1984 Survey Data

1995

Regulatory Scenario	Cost (cents/gallon)	Cost-Effectiveness ($/lb of Emissions Reduced)			
		PM	NOx	PM + NOx	Total Pollutants*
0.05% S					
small refiners	7.3	56.1	-	56.1	2.3
large refiners	2.0	18.9	-	18.9	0.9
0.05% S and 10% Aromatics					
small refiners	11.2	6.7	1.7	2.8	1.3
large refiners	15.2	18.9	4.9	7.8	3.5

* Total Pollutants include sulfur dioxide emissions.

Source: ARB/SSD

2. Capital and Operating Costs

In our cost evaluation, we used NPRA's reported capital and operating costs adjusted for volumes of motor vehicle diesel estimated to be produced by California refineries. Diesel for motor vehicle use produced in California represents about 55 percent of the No. 2 distillate produced. Operating costs were assumed to be proportional to motor vehicle diesel fuel production and capital costs were extrapolated by using a 0.65 exponential scale factor to estimate capital investment. Because the NPRA survey requested cost information only for the 20 percent aromatic hydrocarbon content and the 0.05 percent sulfur content scenario, we were able to perform an analysis only for these two scenarios. The capital and operating costs based on the NPRA results and adjusted for the staff's estimates on California's motor vehicle diesel fuel needs are shown in Table 16.

3. Cost Per Gallon

The results of the staff's adjustments to the NPRA's costs and the resulting cost-effectiveness for the two cases: (a) the 0.05 percent sulfur content and (b) for the 0.05 percent sulfur content with 20 percent aromatic hydrocarbon are shown in Table 17. The average cost for the small refineries for the 0.05 sulfur percent with 20 percent aromatic content case is estimated to be about 70 cents per gallon for small refineries versus 8.1 cents per gallon for large refineries. For large refineries

Table 16

Summary of Cost Analysis Using NPRA Data for
Each Regulatory Scenario for Small and Large Refiners

Fuel Composition Requirement	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
0.05% S					
small refiners	19.5	139.10	95.70	48.23	143.93
large refiners	133.0	90.53	82.13	56.07	138.20
0.05% S and 20% Aromatics					
small refiners	19.5	523.60	358.70	213.10	571.80
large refiners	133.0	457.10	313.20	142.0	455.20

Table 17

Cost-Effectiveness of Emission Reduction from Diesel Fuel Sulfur and Aromatics Hydrocarbon Content Reduction Based on NPRA Cost Analysis

1995

Regulatory Scenario	Cost (cents/gallon)	Cost-Effectiveness ($/lb of Emissions Reduced)			
		PM	NOx	PM + NOx	Total Pollutants*
0.05% S					
small refiners	17.5	169.7	-	169.5	7.1
large refiners	2.5	23.9	-	23.9	1.1
0.05% S and 20% Aromatics					
small refiners	70.0	86.7	22.4	17.9	16.3
large refiners	8.1	10.1	2.7	2.1	1.9

* Include SO_2 redfuctions.

Source: ARB/SSD

having an average cost of 8.1 cents per gallon the range of costs is estimated from 4.4 to 10.6 cents per gallon diesel fuel produced.

4. Cost-Effectiveness

The staff used the costs shown in Table 16 and the emissions reduction estimates from Table 12 to estimate the cost-effectiveness for the NPRA fuel modification scenarios for the year 1995. Table 17 shows the cost-effectiveness for the case that DDAD engine correlations are used and for the year 1990. For the regulatory option of 20 percent aromatic hydrocarbon and 0.05 percent sulfur, the particulate matter emission reduction cost-effectiveness would range from $10.1 per pound for large refineries to 86.5 per pound for small refineries. When total pollutants are considered (including the reductions of SO_2) the cost-effectiveness is changed to $1.9 per pound for large refineries and $16.3 for small refineries. The cost-effectiveness for NO_x ranges from $2.7 to $22.4 per pound of NO_x reduced.

XI. <u>ARTHUR D. LITTLE COST STUDY</u>

A. PROGRAM DESCRIPTION AND STUDY BASIS

In 1987 the Air Resources Board contracted with Arthur D. Little, Inc. (ADL) to estimate the costs of reducing the aromatic hydrocarbon content and the sulfur content of diesel fuels and the aromatic hydrocarbon content of gasoline. The methodology used by ADL in estimating these costs is described below:

<u>Task 1</u>. Based on data from a refinery survey and published sources, ADL characterized the California refining industry into six regional groups based on the refineries' complexity. These groups are: (I) Topping: refineries with simple distillation; (II) Hydroskimming: refineries with distillation plus reforming; (III) Conversion: refineries with fluid catalytic cracking (FCC) and/or hydrocracking (excluding coking); (IV) Deep Conversion: refineries without hydrocracking, similar to III but including coking; (V) LA Basin Deep Conversion: refineries with hydrocracking and coking (some of these refineries have FCC units); (VI) Northern California Deep Conversion: refineries with hydrocracking, same as in V, but all refineries are located in Northern California. This refinery characterization allowed ADL to select a representative refinery from each refinery group and to develop Linear Programming (LP) models that would

simulate each refinery's operations. The LP model involves a modeled representation of refinery processes, yields, and operating costs, and evaluated refinery operations for typical crude oils available in California. The ADL staff calibrated each model against actual 1986 refinery operation data to verify the material balances, process unit utilization, the product specifications, and operating costs. The results were provided to the modeled refineries for comments before being finalized. The calibration results show that the LP models represent the modeled refineries' operations accurately. The LP model results were then extrapolated for all California's refining industry operations for 1986 and were shown to compare well with published data.

Task 2 The ADL staff using the California Energy Commission (CEC) forecasts and other published information estimated the 1991 and 1995 inputs, outputs, and process configurations for all California refineries.

Task 3 The ADL staff researched various process options that are available to refineries for reducing aromatic hydrocarbon and/or sulfur content and incorporated them into the LP modeling methodology. Some process options which ADL considered were purposely excluded because ADL believed that their use would result in increased production of gasoline or lighter products. The ADL constrained the production of all products to existing levels. The new process options that were included in the ADL's analysis are:

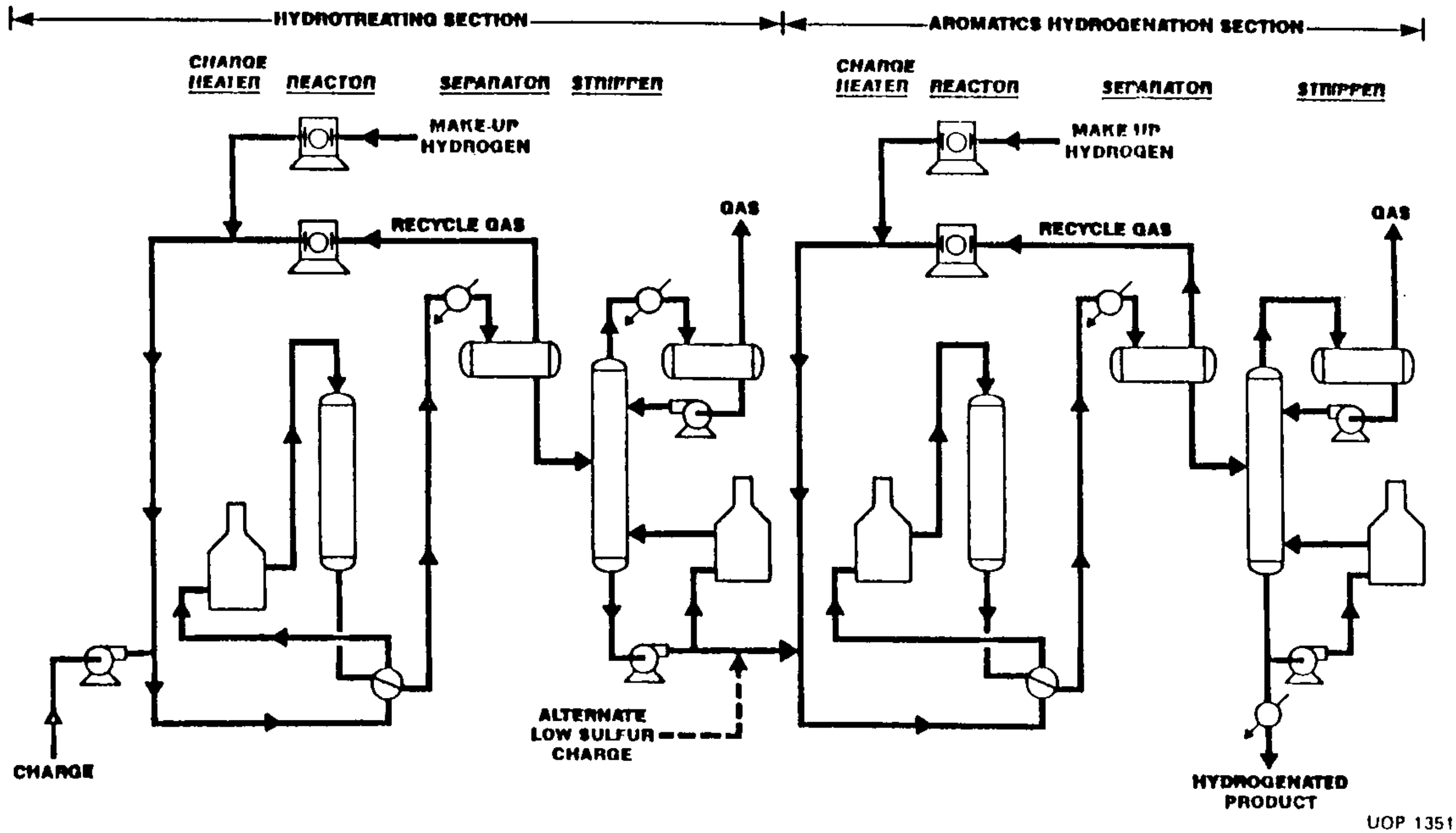
a. Low severity distillate hydrotreating: This is a one stage hydrotreating process which, depending on the sulfur content in the feedstock, can reduce sulfur by 85 to 95 percent. This process has a small impact on product aromatic hydrocarbon content.

b. Moderate severity distillate hydrorefining: This is a one stage hydrotreating process that produces diesel fuels with less than 0.05 percent sulfur. ADL assumed that this process has a small effect on reducing aromatic hydrocarbon content by 5 to 20 percent.

c. To reduce the aromatic hydrocarbon content of diesel fuel by treating with hydrogen, ADL selected the hydrodearomatization (HDA) process. This is a two-stage hydrotreating process. Figure 9 shows an example of this process. The first stage of this process produces a low sulfur/low nitrogen content diesel feedstock to the second stage. The second stage saturates at high pressure/temperature with a noble metal catalyst aromatic hydrocarbons to produce a low-aromatic hydrocarbon content diesel. ADL assumed

Figure 11

UOP AH UNIBON PROCESS



Source: Universal Oil Products (UOP)

that the two-stage HDA process would produce a diesel blendstock with a 10 percent aromatic content if the feedstock to the process is Alaska North Slope (ANS) heavy gas oil or coker gas oil, and a diesel blendstock with a 20 percent aromatic hydrocarbon content if the feedstock to the process is light cycle oil from the FCC process.

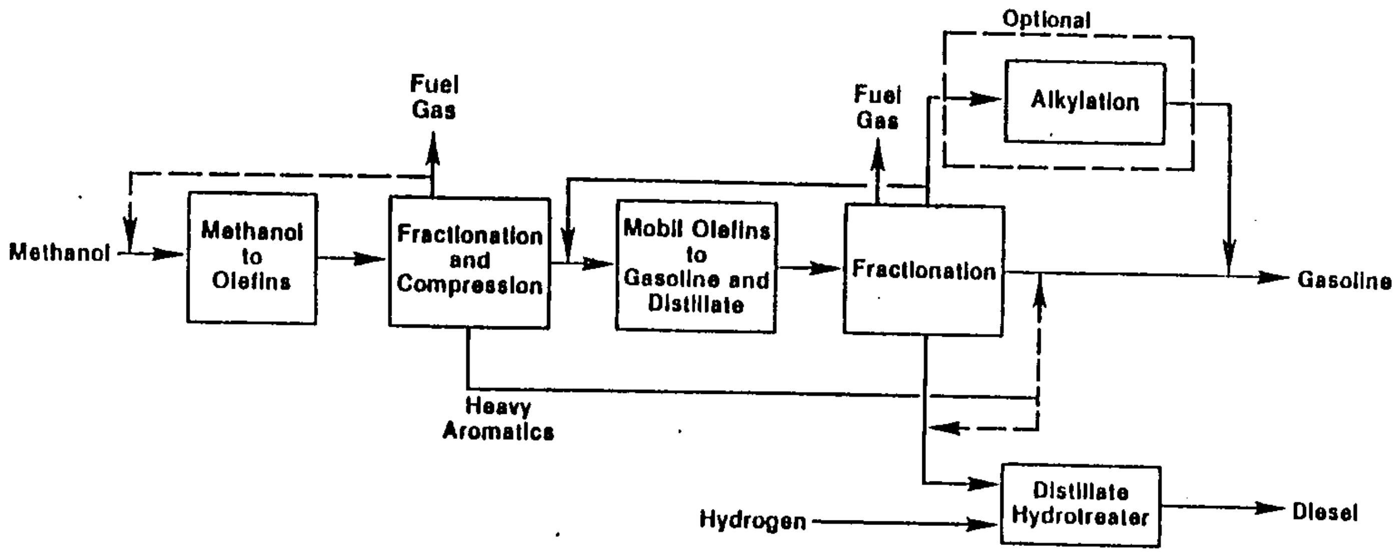
d. Another option that ADL incorporated into their analysis for producing low-sulfur, low-aromatic hydrocarbon content diesel fuel is the Mobil methanol-to-olefins-to-distillate process. Figure 10 shows a scematic of this process. Although this process is much more expensive than the HDA process, this option became economically attractive because ADL assumed a $0.30 per gallon long-term methanol price as compared to about $0.60 per gallon for crude oil. In addition, this option became attractive to the ADL modeling process because the process produces a 3 percent aromatic hydrocarbon content diesel blendstock as compared to a minimum of 10 percent or 20 percent aromatic hydrocarbon content for diesel fuel blendstock produced by the HDA process.

In addition to the new processes discussed above, ADL included in the LP modeling a number non-process options for reducing aromatic hydrocarbon and sulfur content of diesel fuels.

Figure 12

MOBIL

MTO/MOGD PROCESS SCHEMATIC



Source: Mobil Oil Company

The non-process options are (i) the segregation of No. 2 diesel fuel from other distillate products so that only the No. 2 diesel fuel would be required to meet the low-aromatic hydrocarbon/low-sulfur content standards, and (ii) the purchasing of low-aromatic hydrocarbon/low-sulfur blendstocks from outside California.

Task 4 For their cost analysis methodology, the ADL staff targeted different sulfur and aromatic hydrocarbon content values. The sulfur target values ranged from a "maximum achievable with investment" value to the 0.05 percent sulfur value. The aromatic hydrocarbon content targeted limits ranged from the "maximum level achievable without investment" to 10 percent, and included analysis for limits to 20 percent and 15 percent aromatic hydrocarbons as well as a combination of a 0.05 percent sulfur with a 10 percent aromatic hydrocarbons content. The LP models estimated the costs for three diesel production scenarios: (a) A no-segregation scenario where all distillate fuel produced in California is required to meet the low-aromatic hydrocarbon, low-sulfur content limits; (b) the NPRA segregation case where only distillate fuel as reported by the NPRA survey as No. 2 diesel is produced to meet the low aromatic hydrocarbon low-sulfur content limits; and (c) the 50 percent segregation scenario where only the diesel needed for California's motor vehicle diesel fuel demand is produced to meet the requirements for low-aromatic hydrocarbon, low-sulfur limits.

The ADL LP models optimized the cost for producing low-aromatic hydrocarbon/low-sulfur content diesel fuels for each refinery by selecting a combination of process options which is different for each refinery group and for each fuel specification option. In each case, all product values were maintained so that any loss in product volume due to aromatic hydrocarbon removal, sulfur removal or changes in processing severity was replaced by increasing crude oil processing or purchasing outside feedstocks.

B. ADJUSTMENTS TO STUDY RESULTS

The staff made several adjustments to the cost results developed by the ADL in their study. First, in the topping refinery group, a number of refineries produce diesel fuel which does not meet the ASTM standards for motor vehicle diesel fuel. The staff assumed that this diesel fuel is not produced for motor vehicle use and therefore, the costs for reducing its aromatic hydrocarbon and sulfur content were excluded from the staff's cost analysis.

Second, because the staff's 1991 estimate for motor vehicle diesel fuel consumption in California is 152,500 barrels per day and the ADL cost estimate is based on a 297,000 barrels per day diesel fuel production, the ADL capital costs were scaled down based on the ratio of the diesel volume used for motor vehicle fuel to the ADL diesel fuel volume raised to an exponent of 0.65. All other costs were scaled down linearaly based on the motor vehicle diesel volume.

Third, because ADL in their study estimated separately the costs for reducing sulfur content to 0.05 percent sulfur from the costs for reducing aromatic hydrocarbon to 20 percent or 15 percent the staff did not include an analysis for the 20 percent aromatics and 0.05 percent sulfur or the 15 percent aromatics and 0.05 percent sulfur cases.

C. ADJUSTED STUDY RESULTS

1. Capital and Operating Costs

Tables 18 and 19 show the results of the cost analysis for the two regulatory options.

Table 18 shows the estimates for costs for the regulatory option of reducing sulfur content to 0.05 percent by weight. In this cost analysis refiners have been grouped into six groups as in the ADL study. The capital investment is for new processes required for reducing diesel sulfur levels to the targeted values.

Table 18

ADL Cost Analysis Results for
500 Parts per Million Sulfur With Investment

1990

Refinery Group	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
I	3.5	3.6	2.5	30.2	32.7
II	9.8	16.3	11.2	57.9	69.1
III & IV	68.0	75.5	49.7	4.6	54.3
V	39.4	0.0	0.0	0.0	0.0
VI	31.8	33.4	22.9	5.3	28.2
Total	152.5	125.8	86.3	98.0	184.3

Source: ARB/ADL

Table 19

ADL Cost Analysis Results for
500 Parts per Million Sulfur and 10 Percent Aromatic Hydrocarbon
With Investment

1990

Refinery Group	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
I	3.5	60	41	152	193
II	9.8	185	127	428	555
III & IV	68.0	183	126	133	258
V	39.4	197	135	128	263
VI	31.8	166	114	109	223
Total	152.5	793	543	950	1493

Source: ARB adjustments to ADL cost analysis

The increased capital costs shown in Table 19 as compared to Table 18 are the costs of the added process capacity required in order to reduce aromatic hydrocarbon level to the 10 percent level. It is important to note that because ADL, in their analyses have constrained the aromatic hydrocarbon levels achievable by the HDA process to 20 percent for light cycle oil feedstocks and to 10 percent for all other feedstocks, the LP models have incorporated for the 10 percent aromatic hydrocarbon scenario capacity of the Mobil olefins-to-distillate process which produces the low-aromatic hydrocarbon, low-sulfur content diesel. For the 10 percent aromatic hydrocarbon case as shown in Table 19, a significant portion of the total costs estimates for Groups I and II are the operating costs. The high operating costs reflect the costs of the methanol purchased as a feedstock to the Mobil process.

Table 20 summarizes the capital investment and operating costs as presented in Tables 18 and 19 by grouping refineries into two major groups; large and small refineries. Small refineries are refineries with operating capacity lower than 50,000 BPD and include all refineries in the ADL Groups I and II plus two refineries in Group III that have reported capacities below 50,000 barrels per day. All refineries in the Groups IV, V, and VI plus the Group III refineries that have capacities greater than 50,000 barrels per day are included in the large refinery category.

Table 20

Summary of ADL Cost Analysis for
Each Regulatory Scenario for Small and Large Refiners

1990

Fuel Composition Requirement	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
0.05% S					
small refiners	19.5	38.1	26.1	89.2	115.3
large refiners	133.0	87.7	60.1	8.9	69.0
0.05% S and 10% Aromatics					
small refiners	19.5	275.3	188.6	593.2	781.8
large refiners	133.0	517.6	354.4	357.1	711.5

Source: ARB/ADL

2. <u>Costs Per Gallon and Cost-Effectiveness</u>

Table 21 shows the costs in cents per gallon and the cost-effectiveness for the year 1995 as estimated from the cost data in Table 20 and from the 1995 emission reductions estimates as shown in Table 12.

Table 21 shows that the cost-effectiveness of reducing directly emitted particulates by reducing the aromatic hydrocarbon content to 10 percent is for large refineries $15.8 and for small refineries $118.5 per pound of PM_{10} reduced.

The table also shows that the cost-effectiveness of reducing NO_x emissions under the same regulatory scenario is for large refineries $4.1 per pound of NO_x reduced. However, the cost-effectiveness when all pollutants are considered (including reductions in SO_2) is for large refineries $3.0 and for small refineries $22.2 per pound of total pollutant reduced.

D. INDUSTRY CONCERNS

During consultation meetings, representatives of the oil industry expressed concerns with the cost analysis performed by ADL. Discussions of those concerns for three major areas are presented below:

1. <u>Hydrogen Plant Capacity Required</u>

The ADL staff in their methodology for most refinery groups did not require adding hydrogen plant capacity because through hydrogen balance, they estimated that hydrogen will become available to meet hydroprocessing needs. Refining

Table 21

Cost-Effectiveness of Emission Reduction from
Diesel Fuel Sulfur and Aromatics Hydrocarbon Content Reduction
Based on ADL Cost Analysis

1995

Regulatory Scenario	Cost (cents/gallon)	Cost-Effectiveness ($/lb of Emissions Reduced)			
		PM	NOx	PM + NOx	Total Pollutants
0.05% S					
small refiners	14.1	137.7	-	135.7	5.7
large refiners	1.2	11.9	-	11.9	0.5
.05% S and 10% Aromatics					
small refiners	95.5	118.5	30.6	48.7	22.2
large refiners	12.7	15.8	4.1	6.5	3.0

Source: ARB adjustments to ADL cost analysis industry representatives expressed disagreement with this approach and indicated that additional hydrogen plant capacity would be required and should be included in the modeling. ADL, in response, performed a hydrogen plant sensitivity by adding new hydrogen plant capacity to support all new hydroprocessing investment required for each regulatory scenario. This additional cost did not affect costs for Groups I and II because ADL in their original analysis had included additional hydrogen plant capacity. The staff estimates from the ADL sensitivity analysis that the added hydrogen plant capacity would result in an overall cost increase of 22 percent for the 10 percent aromatic hydrocarbon content limit case.

2. Capital Investment Costs

The ADL staff based their estimates of capital investment costs on information provided to them by vendors of process equipment, and added 50 percent for off-sites costs and a 5 percent additional cost for California location. Refining industry representatives expressed the opinion that this methodology underestimates costs by a factor of 2 or 3 because vendors' costs always underestimate the costs to the refineries. We discussed this issue with the ADL staff and they believe that the cost estimates used for their modeling are valid within the range of ± 40 to ± 50 percent.

If capital costs are higher as refining industry representatives claim, the total costs and the cost-effectiveness for each fuel specification scenario will be increased. We performed a sensitivity analysis using ADL's capital cost as a baseline and adding a capital cost increase by 100 percent. Table 22 shows the percent increases for each regulatory scenario as results from this analysis.

The percent increase in total costs resulting from doubling capital costs ranges from 24 percent to 87 percent. The smaller percent increase is for small refineries and for the 10 percent aromatic hydrocarbon content case and is the result of the smaller contribution of the capital cost to the total cost. That is because the ADL analysis show that the major portion of the costs for the small refineries are the operating and the feedstock costs. The percent increases can be applied to the results shown in Table 21 to estimate the cost-effectiveness when the capital costs are doubled.

3. Mobil Methanol-to-Distillate Process - Methanol Price

The ADL methodology in order to meet the 10 percent aromatic hydrocarbon targeted values relied heavily on the Mobil process in order to produce the low-aromatic hydrocarbon, low-sulfur blendstocks needed for the diesel fuel. The reason of this dependency is because the ADL staff has assumed that the HDA process cannot produce diesel blendstocks with aromatic hydrocarbon content below the 10 percent or the 20 percent level, depending on the aromatic hydrocarbon content of the process feedstock. Therefore, the only means of reducing diesel

Table 22

Increase in ADL Costs and
Cost-Effectiveness when Capital Costs are
Increased by 100 Percent

Fuel Composition Requirement	Percent Increase in Total Costs and Cost-Effectiveness
0.05% S	
Small	23%
Large	87%
0.05%S at 10% Aromatics	
Small Refineries	24%
Large Refineries	50%

Source: ARB/SSD

aromatic hydrocarbon level to below the 10 percent remained the Mobil process. Furthermore, because the ADL staff has assumed a long-term price of methanol of $0.30 per gallon, which is significantly less expensive than any other process feedstock, the LP modeling in optimizing costs selects the Mobil process as the most cost-effective option. Oil industry representatives stated that refineries will choose means other than the Mobil process to produce low-aromatic hydrocarbon/low-sulfur diesel and questioned the ADL assumption on the long-term methanol price of $0.30 per gallon.

The ADL staff in response to these concerns on methanol price effects has performed a cost analysis for a $0.70/gal methanol price for the refinery Groups V and VII and for the 15 percent aromatic hydrocarbon and the 10 percent aromatic hydrocarbon regulatory limits.

This analysis shows that for the 15 percent aromatic hydrocarbon content regulatory scenario all Mobil process capacity was eliminated and it was replaced with some additional HDA process capacity. However, the increased operating and feedstock costs offset the lower investment costs and the total cost per gallon was increased by about 90 percent. For the 10 percent aromatic hydrocarbon case the methanol price increase to $0.70 per gallon did not affect Mobil process additions, but it increased dramatically operating costs and resulted in an overall cost per gallon increase by 100 percent.

4. Mobil Methanol-to-Distillate Process - Feasibility

We also received comments regarding the technical feasibility and availability of the Mobil methanol to distillate process. The refining industry representatives requested that we perform a cost analysis by eliminating the use of the Mobil process and replace its capacity with additional hydrodearomatization (HDA) process capacity. Our cost analysis on that basis is presented below.

E. COST ANALYSIS FOR HYDRODEAROMATIZATION ONLY

1. Basis for Analysis

In our cost-analysis we followed a different approach for estimating the costs for the refiners in the small refinery category than for the refineries in the large refinery category group. A detailed discussion of our methodology is presented below. A sample calculation is shown in Appendix E.

a. Small Refineries

For each small refinery, using the ADL baseline data on aromatics and sulfur content of diesel fuel produced, we estimated the required HDR and HDA capacity to produce diesel fuel with 0.05 percent sulfur content, 0.05 percent sulfur and 20 percent aromatics content, 0.05 percent sulfur and 15 percent aromatics content, and 0.05 percent sulfur and 10 percent aromatics content. In estimating the required HDA capacity to meet the targeted values, we assumed that the HDA process will produce diesel fuel with 7 percent aromatics content.

b. Large Refineries

For large refineries, all of the Mobil methanol-to-distillate process additions in the ADL methodology were deleted and replaced by an equivalent added capacity of HDA processes. We assumed that to achieve the same aromatic hydrocarbon reduction as with the Mobil process, the equivalent HDA process capacity would be 2.5 times the diesel production process capacity of the Mobil process as estimated by the ADL analysis. This is based on the assumption that the added HDA processes can produce diesel fuels with a 7 percent aromatic hydrocarbon content versus the 3 percent aromatic hydrocarbon content for the diesel fuels produced by the Mobil process. In addition, in order to include the increased need for hydrogen plant capacity because of the deep saturation of aromatic hydrocarbons by the added HDA process, we increased the hydrogen plant capacity as estimated by ADL, by 20 percent. We also assumed that feedstock costs are zero and other operating and capital costs remain unchanged.

For each refinery we estimated the hydrogen plant capacity required to support all of the new HDR and HDA capacity. Then we used ADL's capital and operating costs and estimated for each small refinery the capital and operating costs of the added HDR, HDA, or hydrogen plant capacity and for each regulatory scenario. As in the previous cost analysis, the cost analysis performed here is for 55 percent of distillate production processed as diesel fuel. The segregation costs are assumed to be significant as compared to the overall costs and were not included.

2. Capital and Operating Costs

Tables 23 through 26 show the results of our cost analysis with: (a) the Mobil process replaced with the HDA process for large refineries, for each regulatory scenario and for each refinery group; (b) our cost analysis for small refineries; and (c) the costs of hydrogen plant capacity to support all new process additions. Overall, our methodology resulted in increases in capital costs for the 0.05 percent sulfur case. For example, our analysis compared to the NPRA results shows that for large refineries the capital costs are increased by about $30 million for the 0.05 percent sulfur case and the capital costs are reduced by about $89 million for the 20 percent aromatic hydrocarbon case. There is also a significant decrease in the operating cost estimates for our analysis. This change is mainly due to our assumption that the feedstock costs are zero for the non-Mobil process case. Overall operating costs estimated by our analysis compared to the costs in the ADL analysis are reduced for small refineries by about $65,000 per day for the 0.05 percent sulfur case, and by $548,000 per day for the 10 percent aromatic hydrocarbon case.

3. Cost per Gallon and Cost Effectiveness

Table 27 summarizes the same costs for each regulatory scenario for the small and the large refineries. Tables 28 and

Table 23

Costs for Producing Motor Vehicle Diesel Fuel
No Methanol-to-Distillate Process
Fuel Requirements: Sulfur Content of 0.05 Percent

1990

Refinery Group	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
I	3.5	18.9	13.0	4.4	17.4
II	9.8	50.1	34.3	12.6	46.9
III & IV	68.0	101.8	69.7	17.8	87.5
V	39.4	0.0	0.0	0.0	0.0
VI	31.8	47.2	32.3	16.4	48.8
Total	152.5	218.0	149.3	51.2	200.6

Source: ARB/SSD

Table 24

Costs for Producing Motor Vehicle Diesel Fuel
No Methanol-to-Distillate Process
Fuel Requirements: Sulfur Content of 0.05 Percent,
Aromatic Hydrocarbon Content of 20 Percent

1990

Refinery Group	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
I	3.5	23.6	16.2	5.1	21.3
II	9.8	71.5	49.0	17.4	66.3
III & IV	68.0	199.3	136.4	48.1	184.6
V	39.4	89.6	61.4	42.4	103.7
VI	31.8	122.9	84.2	28.0	112.2
Total	152.5	506.9	347.2	141.0	488.1

Source: ARB/SSD

Table 25

Costs for Producing Motor Vehicle Diesel Fuel
No Methanol-to-Distillate Process
Fuel Requirements: Sulfur Content of 0.05 Percent,
Aromatic Hydrocarbon Content of 15 Percent

1990

Refinery Group	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
I	3.5	28.3	19.4	6.4	25.8
II	9.8	79.3	54.3	19.0	73.3
III & IV	68.0	249.2	180.7	71.5	242.2
V	39.4	109.5	75.0	54.4	129.4
VI	31.8	184.0	126.0	53.0	179.0
Total	152.5	650.3	445.4	204.3	649.7

Source: ARB/SSD

Table 26

Costs for Producing Motor Vehicle Diesel Fuel
No Methanol-to-Distillate Process
Fuel Requirements: Sulfur Content of 0.05 Percent,
Aromatic Hydrocarbon Content of 10 Percent

1990

Refinery Group	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
I	3.5	32.0	21.9	7.7	29.6
II	9.8	86.5	59.2	22.6	81.8
III & IV	68.0	214.5	147.0	88.0	235.1
V	39.4	195.3	133.8	104.6	238.3
VI	31.8	185.7	127.2	58.8	185.9
Total	152.5	714.0	489.1	281.7	770.7

Soruce: ARB/SSD

Table 27

Summary of Cost Analysis for
Each Regulatory Scenario for Small and Large Refiners
No Methanol-to-Distillate Process

1990

Fuel Composition Requirement	Production Rate (Thousands of Barrels per Day)	Capital Investment (Millions of Dollars)	Capital Costs (Thousands of Dollars per Day)	Operating Costs (Thousands of Dollars per Day)	Total Costs (Thousands of Dollars per Day)
0.05% S					
small refiners	19.5	97.2	66.6	24.7	91 3
large refiners	133.0	120.8	82.7	26.5	109.2
0.05% S and 20% Aromatics					
small refiners	19.5	138.7	95.0	34.9	129.9
large refiners	133.0	368.1	252.1	106.1	358.2
0.05% S and 15% Aromatics					
small refiners	19.5	154.1	105.5	38.8	144.3
large refiners	133.0	496.2	339.9	165.4	505.3
0.05% S and 10% Aromatics					
small refiners	19.5	167.6	114.8	44.6	159.4
large refiners	133.0	546.5	374.3	237.1	611.3

Source: ARB/SSD

Table 28

Cost-Effectiveness of Emission Reduction from Diesel Fuel Sulfur and Aromatics Hydrocarbon Content Reduction Based on Hydrodearomatization Only

1995

Regulatory Scenario	Cost (cents/gallon)	Cost-Effectiveness ($/lb of Emissions Reduced) PM	NOx	PM + NOx	Total Pollutants
0.05% S					
small refiners	11	107.5	-	107.5	4.6
large refiners	2	18.8	-	18.8	0.9
0.05% S and 20% Aromatics					
small refiners	16	31.1	10.0	15.2	4.7
large refiners	6	12.6	4.0	6.2	1.9
0.05% S and 15% Aromatics					
small refiners	18	26.9	7.6	11.8	4.6
large refiners	9	13.8	3.8	6.1	2.3
0.05% S and 10% Aromatics					
small refiners	19	24.1	6.3	9.9	4.6
large refiners	11	13.8	3.5	5.6	2.6

Source: ARB/SSD

29 are the results of the staff's cost analysis and show the costs in cents per gallon and the cost-effectiveness for each regulatory scenario for the years 1995 and 2010.

For the 10 percent aromatics and the 0.05 percent sulfur case our analysis shows an improved cost-effectiveness compared with the ADL analysis shown in Table 21, the most notable example being the small refineries where the cost-effectiveness shows an improvement from $22.20 to $4.60 per pound of total pollutant reduced. Our analysis for the same case for the year 2010 shows that the cost effectiveness improves to $4.00 from $4.60 per pound of total pollutant reduced for 1995.

F. COMPARISON OF THE DIFFERENT COSTS AND THE COST-EFFECTIVENESS ANALYSES

Tables 30 and 31 show a comparison of the results for capital costs and cost-effectiveness by the different cost analysis methods used in this report. For the 0.05 percent sulfur scenario for small refineries, our capital cost estimates are within the range of costs estimated by ADL and NPRA. For large refineries, our analysis shows higher capital costs than for the other methods. For the 0.05 percent sulfur and 20 percent aromatic hydrocarbon case, our capital cost estimates are higher than NPRA's estimates for large refineries ane lower for small refineries. A comparison of our results with ADL's results for the 0.05 percent sulfur and 10 percent aromatic hydrocarbon

Table 29

Cost-Effectiveness of Emission Reduction from
Diesel Fuel Sulfur and Aromatics Hydrocarbon Content Reduction
Based on Hydrodearomatization Only

2010

Regulatory Scenario	Cost (cents/gallon)	Cost-Effectiveness ($/lb of Emissions Reduced) PM	NOx	PM + NOx	Total Pollutants
0.05% S					
small refiners	11	89.6	-	89.6	4.7
large refiners	2	15.8	-	15.8	0.8
0.05% S and 20% Aromatics					
small refiners	16	38.5	7.3	12.2	4.3
large refiners	6	16.9	2.9	4.9	1.8
0.05% S and 15% Aromatics					
small refiners	18	36.1	5.4	9.5	4.2
large refiners	9	18.5	2.8	4.8	2.1
0.05% S and 10% Aromatics					
small refiners	19	34.4	4.5	7.9	4.0
large refiners	11	19.4	2.5	4.5	2.3

Source: ARB/SSD

Table 30

1990 Capital Cost Comparisons

Regulatory Scenario	Capital Costs (Millions of Dollars) 1984 Survey	NPRA Survey	ADL Analysis	ARB Analysis
0.05% Sulfur				
small refiners	28.20	139.10	38.11	97.21
large refiners	104.83	90.53	87.69	120.77
0.05% Sulfur and 20% Aromatics				
small refiners	-	523.60	-	138.66
large refiners	-	457.10	-	368.12
0.05% Sulfur and 15% Aromatics				
small refiners	-	-	-	154.06
large refiners	-	-	-	496.19
0.05% Sulfur and 10% Aromatics				
small refiners	24.00	-	275.32	167.55
large refiners	813.10	-	517.55	546.47

Table 31

1995 Cost-Effectiveness Comparisons

Cost - Effectiveness ($/lb of Pollutant Reduced)

Regulatory Scenario	PM 1984 Survey	PM NPRA Survey	PM ADL Anal.	PM ARB Anal.	NOx 1984 Survey	NOx NPRA Survey	NOx ADL Anal.	NOx ARB Anal.	Total Pollutants 1984 Survey	Total Pollutants NPRA Survey	Total Pollutants ADL Anal.	Total Pollutants ARB Anal.
0.05% Sulfur												
small refiners	56.1	169.7	137.7	107.5	-	-	-	-	2.3	7.1	5.7	4.6
large refiners	18.9	23.9	11.9	18.8	-	-	-	-	0.9	1.1	0.5	0.9
0.05% Sulfur and 20% Aromatics												
small refiners	-	86.7	-	31.1	-	22.4	-	10.0	-	16.3	-	4.7
large refiners	-	10.1	-	12.6	-	2.7	-	4.0	-	1.9	-	1.9
0.05% Sulfur and 15% Aromatics												
small refiners	-	-	-	26.9	-	-	-	7.6	-	-	-	4.6
large refiners	-	-	-	13.8	-	-	-	3.8	-	-	-	2.3
0.05% Sulfur and 10% Aromatics												
small refiners	6.7	-	118.5	24.1	1.7	-	30.6	6.3	1.3	-	22.2	4.6
large refiners	18.9	-	15.8	13.8	4.9	-	3.1	3.5	3.5	-	3.0	2.6

case shows that our cost estimates are higher for large refineries and lower for small refineries.

The cost-effectiveness results shown in Table 31, in addition to the capital costs, reflect the differences in operating costs for the various cost-effectiveness approaches. The table shows that for large refineries, if total pollutants are considered, the cost-effectiveness ranges from $2.60 to $3.50 per pound of total pollutant reduced. For small refineries, the range shown is from $1.30 to $22.20 per pound of pollutant reduced. The $22.20 per pound figure reflects the high feedstock costs in ADL's analysis for small refineries.

G. OTHER SENSITIVITIES

1. Segregation Costs

Our analysis of costs is based on the cost to produce only the volume of diesel fuel that would be subject to the requirements of the proposed regulations. Industry representatives raised concerns regarding the costs that would be incurred because the refining, transportation and distribution sectors of the oil industry would need to segregate the low sulfur, low aromatic hydrocarbon diesel fuels from other grades of distillate fuel. We have discussed this issue with pipeline company representatives. Their view is that the segregation cost would be either non-existent or not significant for the transportation sector. We have performed a cost analysis assuming every refinery will need additional tankage for regulated diesel fuel. We estimated the needed tank capacity as being a 30 day storage capacity. Our capital cost estimates are $3.3 million and $10.7 million for small and large refiners respectively. This would add 0.1 to 0.3 cents per gallon to the cost of diesel fuel produced.

2. <u>Additional Hydrorefining Capacity</u>

At our September 27, 1988, consultation meeting, several refiners stated that the ADL analysis was faulty in that some existing hydrotreating could not be used to reduce fuel sulfur content to the level required of a first stage of an HDA unit, as assumed by ADL. Because of this, the refiners asserted that ADL had underestimated the cost of HDA processing. We used ADL's results as the basis for our cost analysis.

We have performed a sensitivity analysis of the cost of additional severe hydrotreating (hydrorefining or HDR) capacity such that it would act as a first stage of an HDA unit. Our estimates of large refiner costs would increase by up to 20 percent if all refiners would need to add HDR capacity. Because we do not know the extent of the need to add such capacity, we have not included it in our basic cost estimate.

XII. PROPOSED REGULATIONS

A. PROPOSED NEW SECTIONS

The staff is proposing two new sections to the California Code of Regulations (CCR). Those sections are Section 2255 - Sulfur Content of Diesel Fuel, and Section 2256 - Aromatic Hydrocarbon Content of Diesel Fuel. We are also proposing amendments to existing Section 2252. The texts of our proposals are shown in Appendix G. This chapter presents the provisions of the proposed regulations.

B. SUMMARY OF PROPOSALS

Proposed Section 2255 of Title 13, CCR, limits the sulfur content of motor vehicle diesel fuel for use in California to 500 parts per million. Proposed Section 2256 limits the aromatic hydrocarbon content of motor vehicle diesel fuel to 10 percent by volume, except for limited amounts of motor vehicle diesel fuel produced by small refiners (refiners with crude oil capacity less than 50,000 barrels per stream day). Those limited amounts may not exceed an aromatic hydrocarbon content of 20 percent.

The two proposed sections define terms and applicability, and provide for test methods, variances, and in the case of proposed Section 2256, alternative means of compliance.

C. DISCUSSION OF REGULATORY PROPOSALS

Because the proposed regulations both address specifications for motor diesel vehicle composition, many of the provisions of proposed Sections 2255 and 2256 are the same. Many of these provisions are the same as existing Section 2252 which limits the sulfur content of motor vehicle diesel fuel transferred or sold for use in the South Coast Air Basin and Ventura County. Section 2252 has been successfully implemented since January 1, 1985. Proposed Section 2255 is discussed below. Following this discussion, proposed Section 2256 is discussed with reference to the provisions in common with Section 2255.

D. PROPOSED SECTION 2255--SULFUR CONTENT OF MOTOR VEHICLE DIESEL FUEL

1. <u>The Sulfur Content Limit.</u>

The regulation would impose a statewide sulfur content limit on motor vehicle diesel fuel of 500 ppm. As discussed elsewhere in this report, a 500 ppm limit is technologically feasible and would result in significant emissions reductions. A 500 ppm limit is already being met in the SCAB and Ventura County. Standard refinery processes can reduce the sulfur content of diesel fuel by 90 percent. The current Division of Measurement Standards (DMS) limit for the sulfur content of motor vehicle diesel fuel outside the SCAB and Ventura County is 5,000 ppm. A 90 percent reduction of the sulfur content of diesel fuel containing 5,000 ppm would result in diesel fuel containing 500 ppm sulfur.

2. <u>Applicability to All Producers and Importers.</u>

The regulation would apply to all motor vehicle diesel fuel in the state, regardless of who produced or imported the fuel. We believe this is the most equitable approach and will result in the greatest emissions reductions.

The existing regulation for the SCAB and Ventura County has included an exemption for small refiners. In 1985 the Board eliminated the exemption effective January 1, 1989. We believe that the reasons for eliminating the existing small refiner exemption also support not having such an exemption in a statewide regulation. The cost-effectiveness of applying the basic standard to small refiners compares favorably with other measures. An exemption results in substantially greater emissions because the DMS standard permits ten times the sulfur content as our proposed 500 ppm standard. An exemption would also result in an unintended economic advantage for small refiners. Because of the nature of refinery operations, an intermediate sulfur content standard for small refiners does not appear to be a practical option.

3. Compliance Date.

The proposed regulation would require compliance with the 500 ppm sulfur content limit as of January 1, 1993. This compliance date would provide leadtime generally comparable to that provided by previous fuels regulation, and would allow adequate time for large and small refiners to plan and install necessary new refinery equipment or develop alternative markets for diesel fuel. Section 2252 originally provided three and one-half years for large refiners to comply with the low sulfur requirement for diesel fuel in the SCAB and Ventura County. The

1985 amendments similarly provided small refiners three and one-half years leadtime.

Our proposed limits on the aromatic hydrocarbon content of diesel fuel would require somewhat more time because of greater capital equipment requirements for aromatic hydrocarbon content reduction compared to sulfur content reduction. Since many refiners would be expected to use the same refinery processes to comply with both the sulfur and aromatic hydrocarbon limits, it is advisable for both regulations to have the same date for final compliance. We believe that a January 1, 1993, effective date for both regulations would be consistent with the need for expeditious emission reductions and the need of refiners to have sufficient time to plan, design, and have necessary equipment installed.

4. High-Altitude Winter Diesel Fuel.

During the workshop process, some refiners indicated that it is necessary to blend quantities of jet fuel into diesel fuel sold at higher elevations during the wintertime in order to have an acceptable cloud point (the temperature at which wax crystals begin to appear in the fuel). The jet fuel typically has a higher sulfur content, and it may not be economically reasonable to require substantial desulfurization of the jet fuel just to assure that the high altitude wintertime blends meet a 500 ppm sulfur content standard.

We are satisfied that this is a legitimate concern. Therefore, the proposed regulation provides that the 500 ppm standard does not apply where two conditions are met: (1) the person selling the diesel fuel demonstrates that he or she has taken reasonable precautions to assure that the diesel fuel will be dispensed to vehicles only at altitudes of 3000 feet above sea level and only between November 1 and March 31, and (2) the sulfur content of the diesel fuel does not exceed 1500 ppm. We believe this will allow the use of sufficient amounts of jet fuel as a blend component, while having a minimal impact on the overall emissions reductions resulting from the regulation. There is no economic incentive for refiners to increase the amount of the higher sulfur jet fuel blendstock because jet fuel costs more than diesel fuel.

5. Compliance Mechanism.

(a) Flat Limit Applicable to All Motor Vehicle Diesel Fuel.

We propose that the 500 ppm sulfur content standard be a flat limit applicable to all batches of motor vehicle diesel fuel. We believe that this approach has distinct advantages over a regulation which permits averaging or offsetting different sulfur contents of different batches. The flat limit approach is also similar to that taken in all of the Board's other fuels regulations except for the lead content of leaded gasoline standard (13 CCR Section 2253.2), and is the approach that has been implemented successfully in the existing limits on the sulfur content of motor vehicle diesel fuel in the SCAB and Ventura County.

A major advantage of a flat limit is that the regulation can be substantially simpler and more straightforward than one allowing averaging or offsetting. A flat limit avoids the need for complex provisions on how an average is computed or what tests the producers must conduct and report.

Second, enforcement of the regulation can be more effective and less costly. Enforcement personnel will be able to sample diesel fuel in the field and document a violation whenever diesel fuel exceeding the 500 ppm standard is found. These personnel could then take immediate action to see that noncomplying diesel fuel is removed from the market. The staff will not have to rely on the accuracy and integrity of tests and reports submitted by the regulated community.

As part of a recent proposed rulemaking, The U.S. Environmental Protection Agency described the substantial problems encountered in enforcing EPA's quarterly average lead content limits, which also allowed "banking" and "trading" of lead credits. (See 53 Fed. Reg. 17378, 17405 (May 16, 1988).) Recent audits of refiners and importers have uncovered a significant number of unreported violations, including overreporting of gasoline gallonage, misclassification of gasoline and gasoline blending stocks, and underreporting of lead usage. Unreported violations can often only be identified through costly and resource intensive investigations. This is of particular concern since the average lead content regulations had the advantage of cross-checks of lead usage through reports submitted by lead additive manufacturers. In the case of a compound such as sulfur which exists naturally in crude oil, there do not appear to be any available mechanisms which would allow for effective cross-checking.

Third, the ability of staff to verify compliance through direct sampling minimizes the need for industry to submit reports to staff. Since the proposed 500 ppm sulfur content limit will apply to all batches and there will be no separate limit for small refiners, we do not believe that producers or importers need be required to maintain records of sulfur content tests as they have been in the existing regulation for the SCAB and Ventura County.

The advantage of an averaging or offsetting mechanism is that it affords greater flexibility to refiners by allowing them to operate closer to a manufacturing tolerance, thereby reducing costs. However, we believe that refiners are reasonably able to operate in compliance with a flat 500 ppm sulfur content limit, and this has been borne out by the experience in the SCAB and Ventura County.

(b) <u>Applying the Limit Throughout the Distribution Network.</u>

Like the Board's other fuels regulations, the sulfur content limit would apply throughout the diesel fuel distribution network. This enables the enforcement staff to conduct tests and document violations at various points in the distribution process. For instance, "upstream" inspections at refineries can effectively identify large batches of noncomplying fuel before they leave the refinery. "Downstream" samples can help identify the presence of high sulfur diesel fuel originally intended for nonvehicular sources.

(c) Prohibited Transactions.

The proposed regulation prohibits the "sale, offer for sale, or supply" of vehicular diesel fuel exceeding the standard. A definition of "supply" would clarify that the term means to provide or transfer a product to a physically separate facility, vehicle, or transportation system. Because a supply can occur without relinquishment of the product to a separate entity, wholesale purchaser-consumers who fuel their own vehicles would be engaging in a supply. Thus there is no need to have a separate provision on wholesale purchaser-consumers dispensing fuel into their vehicles.

(d) Definition of "Vehicular Diesel Fuel."

The sulfur content standard would apply to "vehicular diesel fuel." The regulation only applies to motor vehicle diesel fuel because the Board has the direct authority to regulate the composition only of those fuels used in motor vehicles. (Western Oil and Gas Association v. Orange County APCD, 14 Cal. 3d 411 (1975)).

The regulation would contain a definition of "vehicular diesel fuel" identical to the existing Section 2252(f)(4) definition of "diesel fuel for use in motor vehicles in the south coast control area" except for changes in the geographic references. Diesel fuel which meets any of three tests would be included in the definition: (1) The fuel is not conspicuously identified as a fuel that may not lawfully be dispensed to motor vehicles in the control area; (2) the seller or supplier knows the diesel fuel will be used in motor vehicles in California, or (3) the seller or supplier reasonably should know the diesel fuel will be so used and s/he has not received a declaration stating that the purchaser or recipient will not sell the fuel for dispensing, or dispense it, into motor vehicles in California. The prohibitions on sales, offers or supplies would apply to diesel fuel which at the time of the transaction is "vehicular diesel fuel."

Substantial quantities of diesel fuel sold in California are used in nonvehicular sources or are shipped out-of-state. However, diesel fuel may pass through several parties during distribution; to the extent that the sulfur content limits increase the price of California vehicular diesel fuel, there is an economic incentive for purchasers to use for California vehicles higher sulfur content diesel fuel that may have been intended for non-vehicular use or sale outside the state. The proposed definition is intended to help assure that sellers of higher sulfur diesel fuel take reasonable precautions against subsequent illegal use of the fuel; if they do not do so, we believe the sale should be subject to the regulation. At the same time, the definition assures that a person taking appropriate precautions is not liable where a subsequent party sells the fuel for use in California motor vehicles. We have not experienced problems with the definition in administering the south coast control area rule.

(e) <u>Presumed Sulfur Content of Diesel Fuel Represented as Being for Nonvehicular Use.</u>

We have experienced instances in the south coast control area in which distributors have acquired diesel fuel labeled as not for use as a motor vehicle fuel in the basin and have then sold it for motor vehicle use in the south coast control area. In virtually all instances, the fuel has been so labeled because it exceeds the sulfur content limit. However, direct test results of the sulfur content may not be available, and one of the elements in demonstrating a violation is proving that the diesel fuel was in fact above the limit. We are therefore proposing that where fuel has been represented as not for use in California motor vehicles, it shall be deemed to exceed the 500 ppm sulfur content limit unless it has been tested and shown to be in compliance.

(f) <u>Sales Attributed to Upstream Vendors.</u>

The regulation would provide that each retail sale of diesel fuel for use in a motor vehicle, and each supply of diesel fuel into a motor vehicle fuel tank, is also deemed a sale by any person who previously sold the fuel in violation of the substantive standards. This provision would help assure that Health and Safety Code penalties apply to persons who sell noncomplying diesel fuel to distributors, service stations or bulk purchaser-consumers. It is based on essentially identical language in Section 2252(d)(6).

Health and Safety Code Section 43016 is the only Health and Safety Code penalty provision applicable to the sulfur in diesel fuel regulation. Section 43016 provides a civil penalty not to exceed $500 "per vehicle." The described provision is intended to assure that the "per vehicle" penalties could apply to a sale of diesel fuel by an upstream seller in violation of the regulation when the fuel is subsequently retailed by another party. The provision would only apply to the upstream seller when his/her upstream sale was itself illegal under the regulation. Additionally, it is the opinion of Board counsel that in actually imposing any penalty, a court would be required to consider pertinent factors such as the total amount of diesel fuel sold, the degree to which the sulfur content exceeded the standard, the economic benefit received from violating the regulation, the willfulness of the conduct, the presence or absence of prior violations by the seller, and the size and financial condition of the seller, and could only impose a reasonable penalty. (cf. People v. Superior Court (Olson), 96 Cal.App.3d 181, 198 (1979).)

6. Test Method.

The test method for determining the sulfur content of diesel fuel would be American Society for Testing and Materials (ASTM) Method D 2622-82, or any other method determined by the Executive Officer to give equivalent results. This is identical to the test method provisions in Section 2252. We have not experienced problems with these provisons.

7. Variances.

The regulation would authorize the issuance of variances in essentially the same manner as presently authorized in Section 2252. We believe that a variance provision is necessary to mitigate, in appropriate instances, extraordinary hardship that could result from application of the sulfur content standards. The situations in which variances can be issued are strictly limited. There have been few variance applications under the existing fuels regulations, and we expect this pattern to continue under a statewide sulfur content limit.

In order to monitor progress towards compliance by January 1, 1993, we propose that the regulation require each producer to submit a compliance schedule. The schedule would be due at the beginning of 1990, with annual updates for the next two years. A variance based on a compliance plan involving the installation of major additional equipment could not be issued if installation of the equipment had not been included in the compliance schedule and updates. We do not believe a variance is appropriate in the absence of timely activity during the available leadtime period.

8. Other.

The proposed regulation includes various other provisions intended to make it more effective and practicable. These provisions are generally patterned after the terms of Section 2252, and have proven to be useful and appropriate.

E. PROPOSED AMENDMENTS TO SECTION 2252--SULFUR CONTENT OF DIESEL FUEL IN THE SOUTH COAST AIR BASIN AND VENTURA COUNTY

In order to avoid potential conflicts between the proposed new Section 2255 and the exisiting limits in Section 2252 on the sulfur content of diesel fuel sold for use in the SCAB and Ventura County, we propose adding a new Section 2252(o) stating that the section does not apply to diesel fuel sold, offered for sale, or transferred on or after January 1, 1993. We also propose a change in the title of the section to reflect the effect as amended.

F. PROPOSED SECTION 2255--AROMATIC HYDROCARBON CONTENT OF MOTOR VEHICLE DIESEL FUEL

1. <u>The Basic Aromatic Hydrocarbon Content Limit.</u>

The regulation would impose a basic statewide aromatic hydrocarbon limit on motor vehicle diesel fuel of 10 percent by volume (a less stringent limit would apply to small refiner diesel fuel as discussed below). The emission reduction and attendant health effects benefits of the 10 percent aromatic hydrocarbon content limitation are the greatest of the limits that we examined. Further emission reductions could be achieved with lower levels of aromatic hydrocarbons, but the technology to reduce the aromatic hydrocarbon contents may not be adequate to achieve much lower levels. As discussed elsewhere in this Report, we believe that a 10 percent aromatic hydrocarbon content limit is technologically feasible and cost-effective measure that will achieve the maximum emission reductions.

2. Less Stringent Aromatic Hydrocarbon Limit for Small Refiners

(a) 20 Percent Aromatic Hydrocarbon Limit.

We recommend that vehicular diesel fuel produced by small refiners be subject to a less stringent 20 percent limit on aromatic hydrocarbon content. The less stringent limit would only apply the small refiner's historic production volume; any diesel produced beyond that amount would be subject to the basic 10 percent limit.

We propose an aromatic hydrocarbon content limit of 20 percent for small refiners so that small refiners can effectively and fairly compete in the motor vehicle diesel fuel market and still reduce emissions. The "unit" or per gallon cost for small refiners to produce motor vehicle diesel fuel by desulfurizing the diesel fuel produced in the small refiner's refinery, and purchasing 10 percent aromatic hydrocarbon content diesel fuel to "blend down" to 20 percent aromatic hydrocarbon content, is about the same as for large refiners' per gallon costs to produce 10 percent aromatic hydrocarbon content diesel fuel.

(b) Definition of "Small Refiner."

The proposed small refiner definition is based on the existing definition in Section 2252, with some modifications. Parallel to the treatment in the current regulation for the SCAB and Ventura County, a small refiner's California refinery could not have a capacity of more than 50,000 barrels per stream day (bpsd) at any time since January 1, 1978. The limit on past capacity prevents a "downsized" large refinery from qualifying for the less stringent limit. The refinery could not at any time since September 1, 1988 (the month we advised industry of this proposal) be owned or controlled by a refiner that at the same time controls California crude capacity over 50,000 bpsd or U.S. crude capacity exceeding 137,500. We believe that refiners not meeting these criteria are likely to have a sufficient ability to integrate operations and to provide financial resources that they should be subject to the basic 10 percent standard. The existing regulation also includes a requirement that the small refiner's refinery has been used at some time from 1978-1980 to produce motor vehicle diesel fuel. Because of the different mechanism we propose for determining the cap on the amount of diesel fuel subject to the less stringent standard, an equivalent requirement is not necessary.

(c) Annual Volume of Diesel Fuel Subject to the Less Stringent Limit.

We recommend that an annual cap be imposed on the amount of vehicular diesel fuel a small refiner could produce under an exemption from the 10 percent standard. This would help limit the amount of diesel fuel sold with a higher aromatic hydrocarbon content. The proposed regulation would set the annual limit at a volume equal to 55 percent of the average of the highest three year annual production volumes of distillate fuel in 1983-1987 at the small refiner's refinery, as reported in required annual reports to the California Energy Commission (CEC). On an industry-wide basis, 55 percent of the distillate fuel produced in California is sold as motor vehicle diesel fuel in the state. Such a cap would allow small refiners access to the less stringent 20 percent aromatic hydrocarbon limits at their historic production levels. Using the volumes in the CEC reports has the advantage of providing fixed, preexisting figures that cannot modified to maximize production under the exemption.

(d) Administration of Small Refiner Limit.

The provisions on administration of the small refiner aromatic hydrocarbon limit are patterned very closely after the provisions in Section 2252.

A refiner seeking to be subject to the 20 percent limit would have to submit an application containing information necessary for the ARB to evaluate whether the refiner qualifies. To ensure accuracy of the data, the application would have to be submitted under penalty of perjury. The Executive Officer would be required to grant or deny the application within 90 days of receipt. The lower 10 percent limit would immediately apply whenever the refiner ceases to meet the small refiner definition. This would assure that a refiner no longer entitled to be subject to the alternative limit could not continue to supply such diesel fuel pending discovery of changed conditions.

All vehicular diesel fuel consecutively produced in a calendar year would be counted against the cap until the annual cap volume is reached, whether or not some batches have an aromatic hydrocarbon content not exceeding 10 percent. The definition of "produce" would be the same as in Section 2252; that definition has proven workable.

As is the case in Section 2252, we propose that the basis 10 percent aromatic hydrocarbon limit apply to diesel fuel supplied from a small refiner's refinery in any quarter where less than 25 percent of the diesel fuel supplied from the refinery was produced from distillation of crude oil at the refinery. We included this provision to ensure that the intent of a separate limit - to allow small refiners to continue to produce and market motor vehicle diesel fuel from operating a refinery - is realized. We do not believe that it is appropriate to provide this consideration if the refinery were to be used as a blending depot.

Small refiners would be required to submit periodic reports similar to those required under Section 2252. The data required to be reported is necessary to help enable the ARB to verify compliance with the regulation. Failure to submit the required data will create a presumption that the diesel fuel was sold in violation of the regulation.

3. <u>Compliance Date.</u>

We propose that the diesel fuel aromatic hydrocarbon content standard become applicable beginning January 1, 1993, for the reasons set forth in the discussion of the compliance date for the sulfur content limits.

4. <u>Compliance Mechanism.</u>

(a) Designated Alternative Limits and Offsetting.

(i) General Approach.

As indicated above, we believe that flat limits are generally preferable to schemes involving averaging and self-reporting. However, we have concluded that imposition of a flat limit for the 10 percent hydrocarbon standard would not allow adequate flexibility for refiners to meet the standard in a cost-effective manner. Thus we are recommending that producers and importers be allowed the option of varying the aromatic hydrocarbon content of batches of vehicular diesel fuel above and below 10 percent.

The proposed approach would allow refiners to sell diesel fuel that is somewhat out of specification and thus operate closer to manufacturing tolerances. Refiners have stated that such an approach could significantly reduce their costs. They would not have to reblend as many batches to bring them into compliance. We believe that our proposed approach will provide a cost-effective means of compliance with the 10 percent aromatic hydrocarbon content limit.

We considered a "pure" averaging mechanism under which compliance with the standard would be determined solely on the basis of the average aromatic hydrocarbon content over some time-period such as a calendar quarter. We do not recommend such an approach as it would be entirely dependent on self-reporting and verification of the accuracy and completeness of the reported data would be extremely difficult. We are recommending a "hybrid" approach which is based on a mechanism in the ARB's lead content of leaded gasoline regulation (Section 2253.2(c), Title 13, California Code of Regulations). A producer or importer would be permitted to sell batches of diesel fuel with a "designated alternative limit" exceeding 10 percent aromatic hydrocarbon content as long as the batch is reported to the ARB and the producer within 90 days before or after transfers sufficient quantities of diesel fuel with lower "designated alternative limits" to offset fully the higher aromatic content. Unless a designated alternative limit is assigned to a batch, the basic 10 percent limit would apply. A producer or importer that chooses to have each batch meet the 10 percent standard would never have to use the designated alternative limit option.

The proposed approach will afford greater flexibility while giving ARB personnel some ability to sample in the field to verify compliance. However, field sampling would be less effective than with a flat limit because of the possible commingling of batches with different designated alternative limits. Field testing would also not be effective in verifying the reported volumes of designated batches. Therefore, we are recommending testing and recordkeeping requirements to enable staff to conduct compliance audits. Such requirements would have to be imposed in any case if a "pure" average were implemented. Even with these safeguards, we are concerned about the degree to which ARB staff can effectively assure compliance. We will closely monitor implementation of the program to determine its effectiveness.

(ii) Reporting and Offsetting Designated Alternative Limit Batches.

Producers and importers would be permitted to assign designated alternative limits to "final blends" they have produced or imported. "Final blend" is defined as a distinct quantity of diesel fuel which is introduced into commerce in California without further alteration which would tend to affect the fuel's aromatic hydrocarbon content. The designated alternative limit could not be less than aromatic hydrocarbon content as shown by the testing required to be conducted.

The producer or importer would have to notify the Executive Officer of the final blend's designated alternative limit and volume. In administering the offset provisions in the lead in gasoline regulation, compliance staff set up a 24-hour system for telephonic notification. Such a system would similarly be made available for notifications under of designated alternative limits.

The notification would have to be received before the start of physical transfer of the diesel fuel from the production or importation facility, and in no case less than 12 hours before the producer either completes physical transfer or commingles the blend. The ARB needs to be notified in sufficient time to have the opportunity to verify compliance by sampling some part of the blend before it has left the facility. At the same time, it would be unduly burdensome for refiners to have to hold a final blend for a substantial period before it is shipped out. We believe that the proposal strikes an appropriate balance between these two objectives. Subsection 2252.2(c)(1) of the existing lead in gasoline regulation has required notification of the estimated lead content and volume at least 24 hours before the start of physical transfer, with follow-up notification of actual values, if different, within 24 hours after the start of physical transfer. We are concerned that permitting revisions to estimated values could enable a producer to change the designated limit after it becomes known that the ARB is sampling the fuel. Therefore we propose not allowing changes of estimated values, but having shorter notification periods.

As in the lead in gasoline regulation, notifications of designated alternative limit batches would be permitted after the specified time periods if the Executive Officer determines the delay was not caused by the intentional or negligent conduct of the producer or imoprter.

We propose that the triggering events for computing the offset period be identical to those in the lead in gasoline regulation. The 90-day offset period would run from the start of physical transfer of the high aromatic hydrocarbon blend to the completion of physical transfer of the low aromatic hydrocarbon blend. These events are reasonable and readily identifiable.

The regulation would expressly authorize the use of protocols between the Executive Officer and an individual producer or importer to specify how the designated alternative limit requirements are applied to the producer's or importer's operations. Terms of the protocol would be limited to specification of alternative events from which notification and offset periods are measured, and allowing flexibility in the deadlines for reporting batches with designated alternative limits to accomodate normal business hours. Essentially identical provisions in the lead in gasoline regulation have proven useful and workable.

(iii) Prohibited Activities Regarding Designated Alternative Limit Batches.

The proposed regulation would prohibit the sale, offer for sale, or supply of vehicular diesel fuel which has been reported pursuant to the designated alternative limit provisions if the aromatic hydrocarbon content exceeds the designated limit, or if the excess aromatic hydrocarbon content is not fully offset. The regulation would prohibit selling vehicular diesel fuel in a blend with a designated alternative limit of more than 10 percent aromatic hydrocarbon if the total volume of the blend sold exceeds the volume reported. It would similarly prohibit selling vehicular diesel fuel in a blend with a designated alternative limit of less than 10 percent aromatic hydrocarbon if the total volume of the blend sold is less than the volume reported. These provisions would protect against misreporting volumes of diesel fuel to which a designated alternative limit has been assigned.

(b) Required Testing and Recordkeeping.

The proposed regulation includes requirements for testing and recordkeeping patterned closely after the requirements in Section 2252(i) and (j). Producers and importers would be required to sample and test each final blend of vehicular diesel fuel for aromatic hydrocarbon content, and maintain for two years records of sample date, product sampled, vessel sampled, final blend volume, and aromatic hydrocarbon content. Producers and importers would be required to provide the records to the ARB within 20 days of a written request. We believe that these provisions are necessary to enable ARB staff to conduct compliance audits, particularly since the designated alternative limit and small refiner provisions make field testing potentially less effective.

Diesel fuel not tested would be deemed to have an aromatic hydrocarbon content exceeding 10 percent, unless the producer or importer demonstrates to the contrary. This assures that producers and importers could not benefit from failing to test noncomplying fuel.

Producers and importers would be authorized to enter into protocols with the Executive Officer to specify alternative sampling, recordkeeping, or small refiner reporting requirements. This would afford flexibility to tailor the requirements to special operational needs.

(c) Other Compliance Mechanisms.

The other compliance mechanisms in the regulation would be identical to those described above in subsection 4 (b)-(f) of the discussion of the sulfur content regulation.

5. Test Method.

The test method for determining the aromatic hydrocarbon content of diesel fuel would be ASTM Test Method D 1319-84, or any other method determined by the Executive Officer to give equivalent results. We are proposing this method even though the scope of the method states that it is not applicable to fuels with final boiling points greater than 600 degrees Farenheit, which is the case with most diesel fuels. We recommend this method because the historical information on diesel fuel aromatic hydrocarbon content is largely composed of measurements using this method. We are continuing to investigate better test methods for diesel fuel aromatic hydrocarbon content and will propose that such methods be used when they are validated.

6. Waivers for Diesel Fuel Containing Certain Additives.

The 10 percent aromatic hydrocarbon limit could be waived by the Executive Officer for a blend of diesel fuel containing an additive if the Executive Officer determines, upon application, that the blend results in no greater emissions of any criteria pollutant, criteria pollutant precursor, or toxic air contaminant than vehicular diesel fuel meeting the 10 percent limit. At workshops on our proposals, some parties requested that the use of additives be allowed as an alternative to aromatic hydrocarbon content reduction. The proposal will allow this as long as it is assured the additives will result in equivalent emissions reductions.

7. Variances.

We propose that the regulation have variance provisions identical to those in the proposed sulfur content regulation.

8. Other.

As in the sulfur content regulation, the proposed aromatic hydrocarbon regulation would include various other provisions intended to make it more effective and practicable. The provisons are generally patterned after the terms in Section 2252.

XIII. IMPACTS OF PROPOSED REGULATIONS

A. EMISSIONS IMPACTS

1. Emissions from Motor Vehicles

The proposed requirements for the sulfur and aromatic hydrocarbon content for motor vehicle diesel fuel would reduce exhaust emissions from diesel vehicles, based on the 1995 emission inventory, as follows:

SO_2 - 80 tons per day

Particulate Matter - 14 tons per day

NO_x - 53 tons per day

2. Emissions from Refineries

Based on data provided by the ADL study, the staff estimated for each regulatory scenario the fuel use requirements for the added new process units. It is assumed that the SCAQMD, the SJV, and the BAAQMD refineries would employ BACT to reduce SO_2 and NO_x emissions. For added process heaters would be limited to 0.5 pounds/MBTU for San Joaquin Valley refineries and to 0.02 pounds/MVTV or refineries in other areas of the state. The sulfur content is assumed to be limited to 100 ppm for the refineries in the SCAQMD and to 0.05 percent by weight for refineries in the SFBA and to 0.1 percent by weight for refineries in the San Joaquin Valley. Table 39 shows the estimates of emissions for the added process units and for the proposed regulatory scenario of 0.05 percent sulfur by weight for

Table 39

Estimates of NO_x and SO_x Emissions from

New Process Units Added

to Meet the Proposal Requirements

	Emissions (Pounds per Day)	
	SO_x	NO_x
South Coast Air Basin	1000	210
San Joaquin Valley	750	460
San Francisco Bay Area	375	150
Statewide	2225	820

Source: ARB/SSD

all refineries, 20 percent aromatic hydrocarbon content for small refineries, and 10 percent aromatic hydrocarbon content for large refineries.

Table 39 shows that the additional statewide SO_x emissions from new process units would be about 1 ton/day. The additional NO_x emissions would be about 0.4 ton/day.

There are maximum emission increases because the analysis above assumes that these emission incerease would not have to be offset. In fact, many refiners would have to offset the emissions from the installation of new equipment. In any case, the emission increases shown in table 39 are small compared to the reductions from the proposed measures.

B. AIR QUALITY IMPACTS

1. PM-10 Ambient Concentrations

We made an assessment of the air quality impacts of the proposed diesel fuel requirements related to reduced emissions of oxides of nitrogen (NO_x), oxides of sulfur (SO_x), and particulate matter from diesel motor vehicles. Reductions of each of these contaminants is expected to reduce total concentrations of ambient fine particulate matter (PM_{10}). Reductions in NO_x and SO_x emissions indirectly contribute to reduced ambient PM_{10} concentrations by reducing the amount of compounds available to react to form nitrates and sulfates, respectively.

To assess quantitatively the air quality impacts, we estimated impacts on PM_{10} concentrations in the South Coast, Bay Area, and San Joaquin Valley Air Basins. For each air basin, an annual average PM_{10} concentration was calculated by averaging the 1986 and 1987 data for all sites that met minimum criteria for available data.* The annual average concentrations of the sulfate, nitrate, and organic components for each air basin were also determined. To estimate annual average PM_{10} concentrations for 1994, the ratio of 1994 to 1987 emissions was multiplied by 1987 concentration of each PM_{10} component. Emissions of SO_x, NO_x, reactive organic gases, and directly emitted PM_{10} were used for calculating the components of sulfates, nitrates, organics, and remaining PM_{10}, respectively. We assumed that the organic, nitrate, and sulfate components resulted from atmospheric reactions of the respective emissions and were not directly emitted.

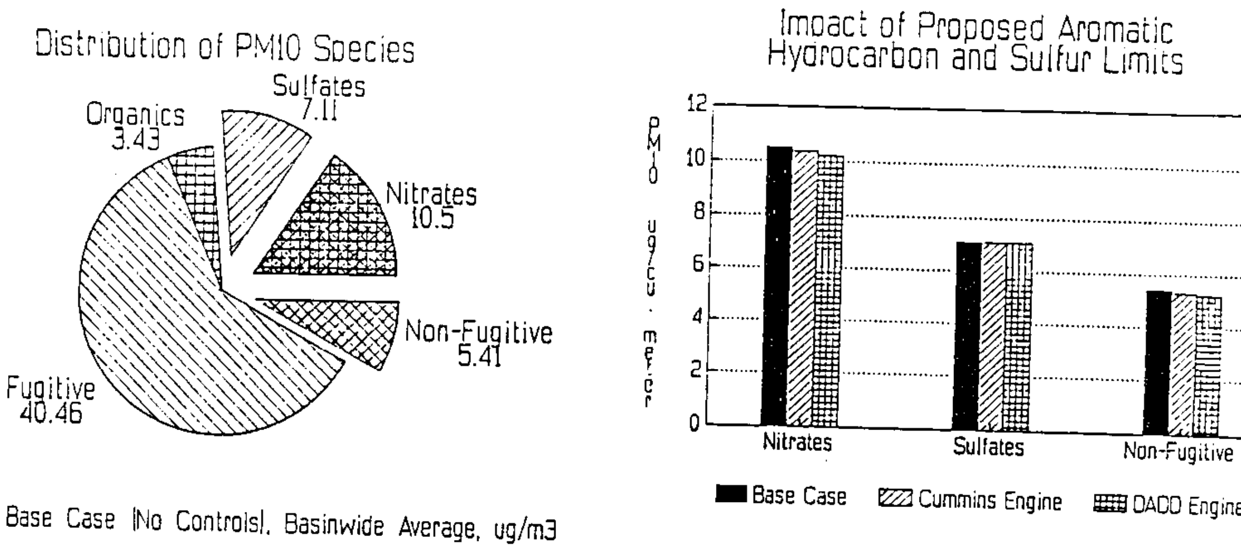
Pie charts of the estimated 1994 annual average PM_{10} concentrations for each air basin are shown in Figures 13, 14, and 15 including the specific organic, nitrate, and sulfate components,

* Criteria utilized in selecting sites for inclusion in the analysis were: 1) sites with representative data for both years, which is defined as having a minimum of 12 samples per calendar quarter; or, 2) sites with at least one year of representative data with the other year having at least two quarters representative data, and the annual average concentrations of the two years within 10 percent of each other.

Figure 13

Impact of Diesel Proposal on
Annual Average PM10 Concentrations

SC - 1994

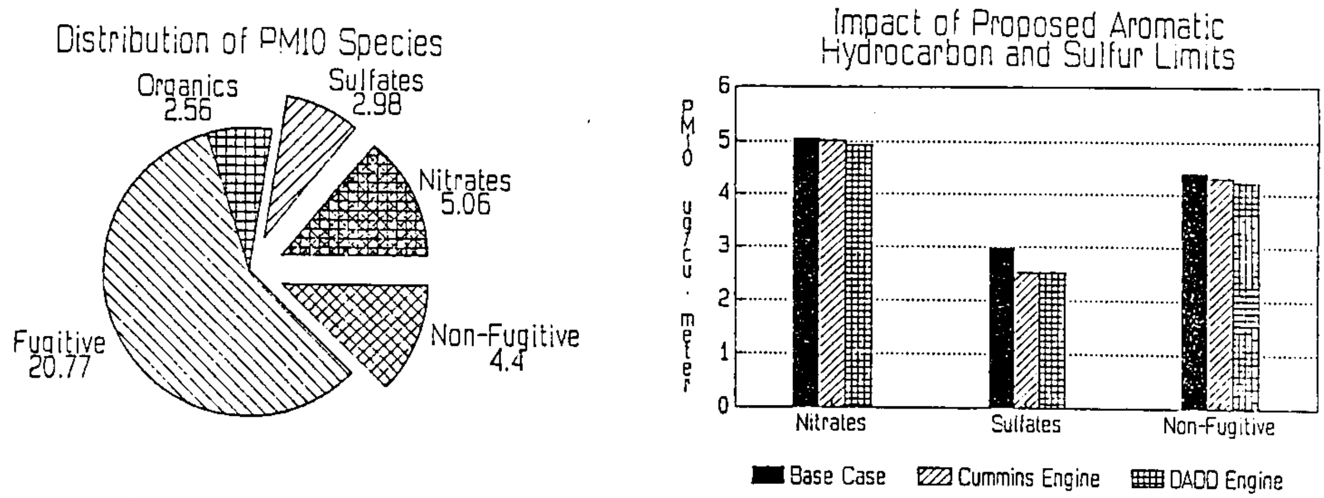


Source: ARB/TSD/SSD

Figure 14

Impact of Diesel Proposal on
Annual Average PM10 Concentrations

SFBA - 1994



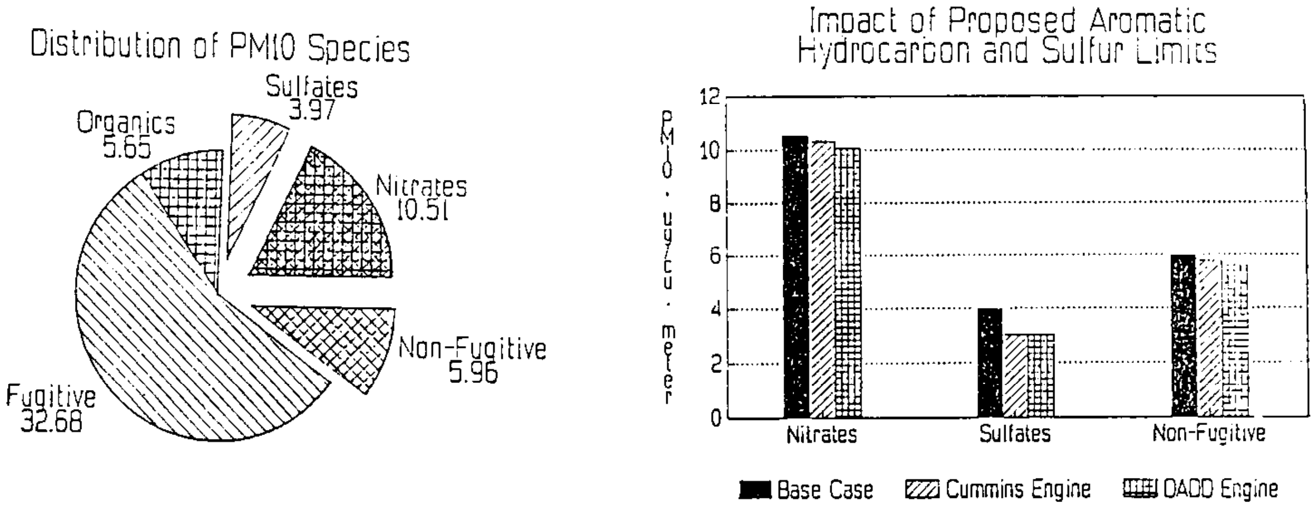
Base Case (No Controls), Basinwide Average, ug/m3

Source: ARB/TSD/SSD

Figure 15

Impact of Diesel Proposal on
Annual Average PM10 Concentrations

SJV - 1994



Base Case (No Controls), Basinwide Average, ug/m3

Source: ARB/TSD/SSD

fugitive dust, and other directly emitted PM_{10}. The proposed diesel fuel composition requirement would reduce concentrations of nitrates, sulfates, and directly emitted PM_{10}. These components are shown as the "exploded" portion of the piechart. Figures 13, 14, and 15 display bar charts showing the "exploded" components and comparing the baseline concentrations to what concentrations would be under estimated minimum and maximum impact of the proposed requirements.

There are additional air quality impacts that can be expected from the implementation of these proposed regulations, but that cannot be quantified. As noted in the ARB report, The Effects of Oxides of Nitrogen on California Air Quality (March 1986), emissions of oxides of nitrogen contribute to increased concentrations of nitrogen dioxide, ozone, acid deposition, and potentially toxic compounds, and to visibility impairment. Any measures that result in reduced emissions of NO_x should also result in reduced concentrations of these air contaminants. The same is true, but to a lesser degree, for reductions in sulfur oxides emissions. There should be benefits in reduced sulfates, acid deposition, and visibility reducing particles.

A final observation should be made with regard to the magnitude of ambient air quality benefits projected from these proposed regulations. Although the proposed regulations may appear to have less than dramatic air quality benefits, the "menu" of strategies currently available for reducing PM_{10} concentrations is not large. Many strategies will be required and the effort to achieve PM_{10} ambient air quality standards is expected to consist of a large number of measures that individually will have small results but collectively will achieve significant reductions. The proposed diesel fuel regulations are in the group of measures that will have the largest, most direct, and beneficial effect for achieving reduced PM_{10} concentrations.

2. Visibility

The visible smoke plumes emitted by diesel vehicles are composed primarily of carbon particles, with a modest fraction of condensed organic compounds. Under normal atmospheric conditions these particles are effectively inert, and remain unaltered as they undergo diffusion, transport, and deposition or washout. They accumulate in the atmosphere in proportion to their mass emission rates, and, by scattering and absorbing light, contribute to the regional haze observed in the South Coast Air Basin, San Joaquin Valley, and elsewhere in California.

A statewide assessment of diesel emission impacts on visibility was compiled by Trijonis [6/]. Trijonis estimated that heavy duty diesel trucks accounted for about 5 to 20 percent of total visibility reduction statewide. Of the 83 sites analyzed, 21 had a diesel contribution below 10 percent, 47 were between 10 and 20 percent, and 15 had diesel impacts greater than 20 percent. These results were in reasonable agreement with data from a few sites where fine particle characterization had been done. Trijonis cautioned that, while the data were adequate for statewide estimates, they were not detailed enough, and contained possible biases that might make data for any one site misleading.

Applying Trijonis' range of estimates of 5-20 percent degradation due to diesels, and the expected 10-17 percent reduction of PM emissions predicted for the proposed diesel fuel requirements, the proposal could improve statewide average visibility from 0.5 to 3.4 percent, depending on location. More detailed analyses by Gray and Cass for the South Coast Air Basin confirm this range of visibility improvement.

C. CANCER RISKS FROM DIESEL EXHAUST

The dose-response relationship between exposure to diesel exhaust and human lung cancer has been estimated by a number of investigators with the results summarized by McClellan[7/]. These dose-response relationships have been derived from epidemiological data, data from animal studies, or the results of short-term tests. Due to gaps in epidemiological information present in the early 1980's, Albert and coworkers[8/] developed a comparative potency method in which data from animal studies and short-term bioassays were used to estimate the risks from exposure to certain substances. The estimated potency values obtained are refrered to as unit risk which as used here is the calculated cancer incidence rate for a large population which is exposed to 1 ug/m^3 of a carcinogen for their entire lifetimes. It can also be considered as the average chance a person has of getting cancer from constantly breathing air containing 1 ug/m^3 of the cancer-causing agent for their entire life. The initial application of this method to diesel exhaust yielded a unit risk value of $2.6x10^{-5}$ times increased lifetime risk per lifetime exposure to 1 ug/m^3 of diesel PM[8/] with diesel PM being a surrogate for total diesel exhaust. Subsequently, the risk from exposure to diesel exhaust was estimated to be $1.2x10^{-5}$ times increased lifetime risk per lifetime exposure to 1 ug/m^3 of diesel PM[9/] using data from a recently completed long-term inhalation study of rats exposed to diesel exhaust[10/]. The factor of two difference in the estimates indicates reasonable agreement, especially in light of the differences in the methods used in their calculation.

Using the above dose-response methods and estimates of the ambient concentration of diesel PM, a risk analysis for exposure to diesel PM in SCAB was performed for each scenario. A slight modification of the lead surrogate model of Trijonis[6/] with a 1980 base year was used to estimate 24 hour annual average diesel

PM concentrations. Diesel PM emissions, a 1980 lead emission rate of 8.32 tons/day for SCAB[11/], and 1980 ambient lead concentration data from 19 sites in SCAB[12/] were used to estimate ambient concentrations of diesel PM for each site. The estimated concentrations were then population weighted using 1980 census data. A SCAB population of 10,246,000 people from 1995-2065 was assumed. The population-weighted annual average concentrations are given in Table 40 for all three scenarios along with the annual averages. These concentrations are in reasonable agreement with others recently published[13/]. The population-weighted 70 year annual average diesel PM concentrations and unit risk values discussed above were used to estimate the increase in the number of lung cancers. The results are given in Table 41. These increases are due solely to exposure to the estimated concentrations of diesel PM over a seventy year lifetime. The risk analysis indicates that between 300-650 lung cancers will occur in the SCAB from exposure to diesel PM for no fuel requirements. The analysis shows a reduction in lifetime cancer risk of 30 to 110 for emissions reductions from the proposed fuel requirements.

Table 40

Population-Weighted Annual Average
Concentrations of Diesel Exhaust PM in SCAB

Year	Ambient Diesel PM (ug/m^3) Baseline	10% Reduction	17% Reduction
1995	2.83	2.55	2.35
2000	2.43	2.19	2.02
2005	2.34	2.11	1.94
2010 to 2065	2.42	2.18	2.01
70 Year Average	2.44	2.20	2.03

Source: ARB/RD/SSD

Table 41

Estimated Increase in the Number of Lung Cancers in SCAB Due to Diesel PM

Unit Risk Increased Lifetime Risk / ug/m^3	Increased Number of Lung Cancers Based on 70 Year Exposure		
	Scenario 1	Scenario 2	Scenario 3
$2.6x10^{-5}$ [a]	650	586	541
$1.2x10^{-5}$ [b]	300	270	250

a Best Estimate
b 95% Upper confidence Limit

Source: ARB/RD/SSD

D. ECONOMIC IMPACTS

1. Pass-Through Costs

We believe that the affected refiners will be able to pass the cost of control to their diesel customers through higher prices. The price increase depends on the cost increase passed on to the customers by the market leaders, usually the large refiners. Based on our analysis, the price increase would be about 11 cents per gallon. This price increase pertains to the large refinery scenario which requires fuel composition of 0.05 percent sulfur and 10 percent aromatic hydrocarbon.

Most users of diesel fuel are engaged in activities which are intermediate steps towards final consumer products or public transit. For example, transportation of processed foods is an intermediate step for providing foods in grocery stores. The portion of the diesel cost in the final price of the products is small enough to make the effects of the control cost on the the final price negligible.

We conclude that the refiners could pass the cost of the control to their customers through a price increase of 11 cents per gallon without significant impacts. (See Table 42 for more details of the cost increase significance.)

2. Impacts on Transportation Using Diesel Trucks

The 1982 Census of Transportation for California reported 155,900 diesel vehicle engines in the state. Of this number, 33,300 units were pickup, panel, or utility trucks and station wagons, referred to as trucks. The Census also reported the number of trucks engaged in transportation for several sectors of the California economy. Table 42 summarizes the data.

Diesel trucks travelled an average of 42,800 miles in 1982. We multiplied this average by the number of trucks in each of the sectors to estimate the total truck miles travelled in 1982. Then we divided this product by 5 miles per gallon (estimated diesel engine fuel economy) to derive the diesel consumption by sector. The average increase in diesel price due to control costs is 11 cents per gallon. We calculated the cost of control to each of the sectors by multiplying the sector's diesel consumption by the increase in price of diesel caused by the control costs.

The last column of Table 42 shows the increased cost of motor vehicle diesel fuel for each sector of the economy, expressed as a percentage of sales, or receipts for that sector. Thus, as an example, the increased cost of cleaner diesel fuel for agriculture constitutes 0.11 percent of the gross cash receipts from agriculture. In all sectors that were examined, the cost of cleaner diesel fuel amounts to less than 0.50 percent of the gross receipts or sales for that sector.

Table 42

Effect on the Economy of Diesel Fuel Improvement in California

Sector	No. of Trucks a (x1000)	Estimated Mile b (x1000)	Cost Increase b (x$1000)	Increase As a Percent b of Sales
Agriculture	17.3	740,440	16,300	0.11 c
Forestry and Lumber	1.4	59,920	1,300	0.05
Construction	18.3	783,240	17,300	0.33 d
Manufacturing	8.3	355,240	7,800	0.02 e
Wholesale Trade	16.9	723,320	15,900	0.007
Retail Trade	8.7	372,260	8,200	0.007
For Hire	47.1	2,015,880	44,400	Note f
Utilities	1.7	72,760	1,600	N.A.
Daily Rentals	3.6	154,080	3,400	N.A.
Others	32.6	1,395,280	30,700	N.A.

NOTES:

a. Source: 1982 Survey Transportation, California, U.S. Bureau of Census and Califorina Statistical Abstract, California Dertment of Finance.
b. See text for discussion of assumption.
c. The cash receipts from farm marketing was used in place sales
d. The total valuation of new housing was used.
e. The toal value added by the manufacturers was used.
f. Sales data was not available. As an alternative measure, the cost increase will be $12 per registered commercial vehicle per year.

N.A. means appropriate data for comparison was not available.

Source: ARB/RD/SSD

Additional information on motor vehicle fuel usage and cost impacts may be derived from the Transportation Census. The Census shows that the total number of trucks in use, excluding pickups, panels, utility truck, and station wagons, exceeds the reported number of diesel engines. This is because the data includes gasoline engines. Table 43 lists the product categories which we believe have a higher concentration of diesel engine trucks. We also present average cost of control per truck used in each category.

Table 43 shows that in most of the business activities the cost of the control per truck is about two dollars per day or less. This cost increase should not affect the business activities significantly.

Table 43

Trucks, Truck Miles, Average Truck Miles, and
Control Cost Increase Estimates for Truckers by Product Category
(Trucks and miles for 1982)

Products Carried	Truck Miles (millions) A	Ave. Miles Per Truck (x1000) B	Diesel Use (gal/yr) C	Ave. Cost Increase ($/truck) D	Cost Increase Per Category (x$1000) E
Farm products	936.0	23.0	4600	507	20,620
Live animals	86.5	11.7	2338	258	1,910
Mining products	21.9	31.3	6257	689	480
Forest products	96.7	34.5	6907	761	2,130
Lumber & Wood Products	190.3	19.2	3844	424	4,190
Processed Foods	1460.4	27.6	5520	607	32,180
Textile mill products	103.1	20.2	4043	445	2,270
Paper products	168.3	28.1	5610	618	3,710
Chemicals	349.6	30.7	6133	676	7,700
Petroleum	272.6	30.0	5991	660	6,010
Plastics & rubber	125.1	27.2	5439	599	2,760
Primary metal products	266.9	30.0	5998	661	5,880
Fabricated metal prod.	228.6	17.3	3464	382	5,040
Machinery	243.1	17.2	3448	380	5,360
Transportation equipment	223.3	16.8	3358	370	4,920
Scrap, or garbage	211.5	11.9	2376	262	4,660
Mixed cargoes	1309.2	43.6	8728	961	28,840
Other	104.7	16.1	3222	355	2,310

NOTES:

1. The data for columns A and B are from the 1982 California Census of Transportation, U. S Bureau of Census. The data excludes pickups, panel and utility trucks, and station wagons which were also surveyed.
2. Column C is calculated as column B divided by 5 which assumes the trucks get 5 miles per gallon (MPG) of diesel. Some trucks are more efficient and get more than 5 MPG. Thus, the estimates of fuel use may be high.
3. Control cost increase per truck, in column D, is the multiplication product of column C and control cost of 11 cents per gallon.
4. Column E is the result of dividing column A by 5 MPG and multiplying by 11 cents/gallon cost of control, while adjusting for proper units of measurement.

Source: ARB/RD/SSD

3. Impacts on Transit Districts

Transit districts in California receive funds from the state and the federal governments in addition to collection from passenger fares. The State's Mills-Alquist-Deddeh Act provides "funding equal to one quarter of one percent of a county's retail sales tax revenues" to local public transportation planning agencies. In 1986-1987 fiscal year, these agencies received about $572 million from the state and $1,714 million from the federal government for transit (84 percent) and non-transit (16 percent, mainly for streets, pedestrian, and bikepaths) uses. The local agencies collected $2,286 million in revenues from all sources (including fares), and spent $1,897 million on operations and maintenance for the fiscal year. The remainder of the revenues were spent on capital outlays.

To illustrate the impacts of the proposed regulation, we present data on operation (number of vehicles, miles, and diesel use), and expenses for seven California local transit districts in Table 44. These seven districts represent relatively small (Fresno), and large (So. California) transit districts.

The operation data is for fiscal year 1981-82. The expense data are for 1986-87. The California Department of Transportation reports increases in ridership of 10.8 percent in 1983, 7.6 percent for 1984, decreases of 0.6 and 5.3 percent for

1985 and 1986. The net change from 1982 to 1986 is an increase of 9.5 percent. We assumed that this increase in ridership was absorbed by the same number of operating vehicles and miles travelled as in 1981-82. That is, the increase in ridership did not increase the 1986-87 diesel usage significantly from 1981-82. Thus, we can compare approximately the operation data in Table 44 with the expense data.

The control cost borne by the transit districts was calculated by multiplying the diesel fuel usage with the price increase of 11 cents per gallon, associated with cleaner diesel fuel. Then we calculate this fuel cost increase as a percentage of the total expenses the transit districts had in 1986-87.

Table 44, column E, shows that the diesel price increase would have about half of one percent impact on the total expenses incurred by the districts. In the 1986-87 fiscal year, public transit passengers paid, on the average, about 23 percent of the total operating revenues. If the diesel fuel cost increases are passed proportionately to the passengers, the fares would increase, on the average, by a negligible range of 0.15 (Golden Gate) to 0.22 (Fresno) percent. This increase is about two-tenths of a penny on a typical $1 fare.

Table 44

	No. of Revenue Vehicles A	Total Miles (1000) B	Diesel Use (1000) C	Total Expens. ($1000) D	Percent Increase in Total Expenses (%) E
AC Transit, Alameda & Contra Costa	835	31,899	7,634	114,162	0.7
Fresno County Transit System	103	3,391	1,205	14,637	0.9
So. California Rapid Transit	2,960	104,506	29,366	534,523	0.6
Orange County	497	14,615	5,604	89,636	0.7
Sacramento Rapid Transit	238	8,545	2,097	33,680	0.7
San Diego Transit Corp.	341	10,424	2,803	41,555	0.7
Golden Gate Transit District	279	9,249	1,748	41,120	0.5

NOTE:

1. The data for columns A, B, and C are for 1982 and from National Urban Mass Transit Statistics, U.S. Dept. of Transportation.

2. The data for columns D are for fiscal year 1986-87 and are from Annual Report, Financial Transactions Concerning Transit Operators and Non-Transit Claimants, California State Controller's Office.

ARB/RD/SSD

E. OTHER IMPACTS

4. Visibility Benefits

People value good visibility and studies have shown that people are willing to pay for visiblity improvements. In urban areas, the willingness to pay for better visibility manifests itself in increased property values. Both property value studies and surveys of householders' preferences have been conducted in recent years that estimated the value of visibility improvement to residents of the South Coast and San Francisco Bay Area air basins. Estimates of householders' willingness to pay for an improvement of one mile in visual range varied from 8 to 69 dollars per household in the SoCAB. In the SFBAAB, estimates ranged from $18 to $45 for a one mile improvement in visible range (Rowe, et al., 1986; Brookshire, et al., 1979; Loehman, et al., 1981; Trijonis, et al., 1985).

Preliminary estimates of the annual dollar benefits of visibility improvements resulting from the proposed diesel fuel rule, range from $5-47 million to householders in the SoCAB, assuming visual range is increased by 1.6 percent in the Basin.

Preliminary estimates of SFBAAB householder benefits range from $3-7 million per year, assuming that the annual average value of visual range in the Bay Area improves by 0.5 percent due to the diesel fuel rule.

The value of good visiblity to recreators has also been studied. Recreators often drive considerable distances to good visibility areas to enjoy hiking and viewing scenery in clear air conditions. Studies conducted of visitors in parks and recreation areas of the Southwestern U.S. found that park visitors would be willing to pay an additional park entrance fee to avoid reduced visibility. Estimates ranged from $0.03 to $0.015 per visitor party per day to avoid a one mile reduction in visual range. (Rowe, et al., 1986; Randall, et al., 1974; Brookshire, et al., 1976; Rowe, et al., 1980; and Schulze et, al., 1981). Applying these benefit estimates to the numbers of National Park and Forest visitors in California, gives the preliminary estimate of $300 to $900 thousand per year for a 0.5 percent visibility improvement in the parks.

Finally, good visibility is of significant value to commercial and governmental entities, although it is difficult to place a dollar value on such benefits. Sectors which rely on and value good visibility include: tourism (the perception of clean, healthy air may be extremely important to businesses which serve visitors), private and commercial aeronautical operations and defense aeronautical testing, including photographic and visual testing of weapons systems.

5. Benefits from Reduced Soiling

Diesel vehicles emit an oily carbon soot which, over a period of hours to days, settles out of the atmosphere soiling walls, windows, fabrics and numerous other objects. Because of its oily component, diesel soot has a tendency to smear and is more difficult to remove than dry particles. Diesel soiling results in an increased requirement for: washing both the interiors and exteriors of buildings, laundering and cleaning of materials, painting of buildings, and washing of motor vehicles. The average householder's maintenance and cleaning costs resulting from diesel soiling have been estimated to range from $5.50 to $65 per year for an change of one microgram per cubic meter in the annual average diesel particulate concentration (Sawyer and Pitz ,1982). Additional costs are associated with the soiling of public, commercial, and industrial buildings and their contents.

XIV. SIGNIFICANT COMMENTS AND RESPONSES

At the workshops held to discuss the basis of the staff's proposals, we received a number of verbal comments related to the feasibility, cost, and effectiveness of implementing requirements for the sulfur content and aromatic hydrocarbon content of motor vehicle diesel fuel. Those comments, together with our responses, are presented below.

Comment: There is no commercially available technology to accomplish reductions of diesel fuel aromatic hydrocarbon content to 10 percent.

Response: In its linear programming analysis, Arthur D. Little (ADL) used two basic processes to reduce the aromatic hydrocarbon content of diesel fuel to 10 percent. Those processes are the Mobil olefins-to-gasoline and distillate process, which uses methanol as a feedstock, and several hydroprocessing options which use hydrogen and a catalyst to reduce the aromatic hydrocarbon content. Neither the Mobil process nor the hydrodearomatization, a type of hydroprocessing that would be used to reduce the aromatic hydrocarbon content of diesel fuel to 10 percent, is currently in use to produce low-aromatic hydrocarbon content diesel fuel.

At the June 27, 1988, consultation meeting to discuss the preliminary results of the ADL study, a refinery representative requested that we re-evaluate the osts of reducing the aromatic hydrocarbon content using "more conventional technology," i.e., hydroprocessing. We have done so, basing our analysis on the proprietary UOP process, "A-H Unibon." That process, generically a hydrodearomatization process, has commercial operations in place to reduce the aromatic hydrocarbon content of jet fuel. The feed for this process is kerosene which is a distillate oil with a lower boiling range than No. 2 diesel fuel.

We believe that the hydrodearomatization process can be readily applied to diesel fuel. In our 1984 refiner survey, we asked refiners for their cost estimates to reduce the sulfur content and aromatic hydrocarbon content of diesel fuel to various levels, including 10 percent aromatic hydrocarbon content. We received 11 responses from refiners. Several refiners provided detailed cost estimates for reducing diesel fuel aromatic hydrocarbon content to 10 percent by using hydroprocessing technology. No refiner responded that it was technically infeasible to reduce to 10 percent the aromatic hydrocarbon content of diesel fuel.

The summary of our 1984 survey results is contained in Table 17, Chapter X. The average reported cost increase to produce motor vehicle diesel fuel with 0.05 percent sulfur and 10 percent aromatic hydrocarbon content was 15.2 cents per gallon for large refiners and 11.2 cents per gallon for small refiners. Investigators from Chevron Research, in an SAE paper titled "Cost-Effectiveness of Diesel Fuel Modifications for Particulate Control", reported that the survey results matched well with Chevron's internal estimates of the costs to reduce diesel fuel aromatic hydrocarbon content to 10 percent.[5/]

<u>Comment</u>: Among the diesel fuel properties that affect particulate matter emissions, sulfur has the greatest impact. Additional particulate matter emissions reductions that can be obtained from reducing the aromatic hydrocarbon content of motor vehicle diesel fuel are less than can be obtained from reducing the sulfur content. The cost-effectiveness of the additional processing to reduce the aromatic hydrocarbon content, over and above the cost to reduce the sulfur content, should be examined.

<u>Response</u>: Our analysis of cost-effectiveness for the South Coast Air Basin (SCAB) is an "incremental" cost analysis of reducing the aromatic hydrocarbon content of motor vehicle diesel fuel. Because the diesel fuel in the SCAB already has reduced sulfur, the predictive equations attribute all of emission reductions to fuel aromatic hydrocarbon reduction only.

<u>Comment</u>: The staff's cost estimates are low. The ADL study underestimates costs. There should be an analysis of the effect doubling the capital cost and adding additional hydrogen production capacity.

<u>Response</u>: We have incorporated such an analysis in this report.

<u>Comment</u>: The staff, in evaluating the CRC data, did not include sulfur as a variable in developing a predictive equat[illegible] for particulate matter emissions from the C[illegible] engine. [illegible] [illegible] have shown that sulfur is an import[illegible]

[illegible]

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9. percent, rather than 95 percent as used in the staff analysis, would show the importance of fuel sulfur content.

Response: In our original statistical analysis of the CRC data, we used a significance criterion of 95 percent. This was an a priori criterion, and if a variable did not meet that test, we did not include it. However, we recognize that from an engineering standpoint, sulfur is an important variable in producing particulate matter emissions. We have modified our analysis to include sulfur variables for both of the CRC test engines. Other variables were not considered important based on the theories of particulate matter formation.

Comment: The estimated volume of diesel fuel that would be subject to the proposed requirements is too low. The underestimate is mainly from an underestimate of on-highway diesel fuel consumption.

Response: We obtained our estimates of on-highway diesel fuel consumption from taxable diesel fuel sales as supplied by the Board of Equalization.

Comment: The cost to consumers will be the cost to the marginal producer of diesel fuel. The marginal producer is the highest cost producer of diesel fuel.

Response: The staff believes that the cost to the consumer will be set by many market forces. Refiners pass on their costs through all of their products. For example, it may be easier for an oil company to increase, by a smaller per gallon amount, the price of gasoline, which is a much greater volume product, than to pass through the entire cost of diesel fuel production to diesel fuel consumers. This appears to have happened in the case of other regulations adopted by the Board.

Comment: The staff has underestimated capital costs in two ways. First, there should be increased costs of 30 percent because of escalation in construction costs. Second, the capital cost should be increased by 63 percent to account for the fact that new technology would be required.

Response: The comment on escalation in construction costs is based on a forecast that there will be heavy construction demand in the early 1990's because of possible EPA action on the sulfur content of diesel fuel. Regarding the cost of new technology, the hydrodearomatization process that we expect would be used to meet the low aromatic hydrocarbon content limit is not truly "new technology", but a new application of existing technology. We prepared cost estimates of using hydroearomatization as a technology to reduce aromatics content based on a request from a refinery representative to use "more conventional" technology, that is, hydroprocessing. Nonetheless, we have performed a sensitvity analysis, shown in Chapter XI, of the cost and cost-effectiveness impacts of doubling the capital cost. The construction cost escalation and new technology cost increases lie within the scope of that sensitivity analysis.

Comment: The staff's analysis of the CRC data should include the effect of the time the data were taken to account for drift in emissions from the engines over time.

Response: We have evaluated the effects of time in changes in emission rates from the CRC engines. That evaluation indicates that the analyses contained in this report adequately reflect the emissions response of the engines to changes in fuel quality.

Comment: The staff's analysis should be a "global" analysis, that is, it should include the fuel effects on both engines in one statistical matrix.

Response: Fuel effects on emissions are known to be engine-specific. We believe that our approach is appropriate in analyzing emissions, especially when one considers that future engines, which we have represented with the DDAD engine, will be different than current engines. Our emission reduction estimates are based on separate evaluations of current and future engines and the effects of fuel quality on those engines. We have made our emissions reduction estimates "global" by estimating the mix of those vehicles in the future vehicle fleet.

Comment: Severely hydroprocessed diesel fuel, such as would be produced in response to the low-aromatic hydrocarbon content requirement, has poor lubricity performance when compared to current diesel fuels. This could have severe negative impacts for the fuel handling systems of diesel vehicles.

Response: We question the applicability of the method the commentor used to quantify the lubricity of diesel fuels as it relates to effects on diesel vehicle fuel pumps. The severly hydroprocessed fuel was "doped" with a sulfur-bearing compound before testing. We do not believe that such a fuel truly represents fuel that would be sold in California to meet the proposed requirements, and the effect of the added sulfur compound on lubricity is unknown. In any case, we believe that additives to the fuel can be used to overcome any lubricity problems.

Comment: The ARB staff has underestimated costs by not increasing the per unit cost of hydrodearomatization capacity to reduce the aromatic hydrocarbon content to 7 percent.

Response: We recognize that there will be some increase in the per unit cost to reduce the aromatic hydrocarbon content to 7 percent, compared to 10 percent. However, the reduction to 7 percent was performed only on a portion of the diesel fuel product, and we believe that we have been conservative in other estimates of HDA processing, as outline in Appendix E.